Arthur F. Dalton

arc perimeter -
Black - Brombach
Gray Ferree
Stereocampimeter
Tangent Screen (Black Felt

PERIMETRY and INTERPRETATION of the VISUAL FIELDS

compiled by

Dr. R. Teshima

P E R I M E T R Y

I. INTRODUCTION

A. Definitions:

PERIMETRY -- A study of the central and of indirect vision, or that part of the field from which the eye at rest can receive impressions.

CAMPIMETRY - The measurement and charting of the visual fields near the point of fixation.

The series of findings known today as the analytical routine all deal with the neuro-psychological act of brain disbursing nervous impulses to various ocular functions after receiving impulses from the macular region only. This is very valuable information, but it tells us little or nothing of the affections of the peri-macular and peripheral portions of the retina. The information gained from an orderly investigation of the whole retinal area will greatly enhance an examiner's skill in solving visual problems, and in many cases will be the means of phenomenally aiding people, even to the degree of saving life.

Perimetric and campimetric tests are determinations of the character and extent of the indirect field of vision. The campimetric test, however, is confined chiefly to the central field.

The method of testing is subjective and consists in obtaining the patient's report of the appearance or disappearance of an object of a certain color subtending a certain angle at the nodal point of the eye. The colors of the test objects most commonly used are white, blue, red, and green. When the white test object is employed, the test is generally called the form field test, while the tests with the colored test objects are termed the color field tests.

The visual field is to be considered as the projection (through the nodal points of the eye) in space of all the retinal points capable of being stimulated by light. For example, the temporal field is a projection of the nasal part of the retina, the superior field is a projection of the inferior part of the retina, and so on. Hence, the normal physiological blind spot area in the field of the left eye will always appear to the left of the point of fixation; and vise versa for the right eye. In making campimetric studies, we are concerned only with the detailed examination of that portion of the total visual field which extends within 30 degrees to 40 degrees of the point of fixation. Studies of this portion of the visual field are especially important in all pathological conditions affecting the retino-cerebral system. Deficiences of function manifested within this area possess great significance with regard to visual and ocular behavior. Within

6. Should take fields in case of incipient cataract.
7. Before starting a program of V.T.
8. Any case with severe headaches and complaints of loss of vision at one side.

this area are contained the macular region, the physiological blind spot and the clinical color fields.

In order to obtain full benefit from the findings obtained in any examination of the visual fields it is necessary that one be familiar with the anatomical structure and normal function of the retino-cerebral system. It is desirable to know, for example, the relative distributions of rods and cones in the fovea and periphery of the retina, the distribution of the fibers from the retinal ganglionic cells as they course over the retina and as they pass along the optic nerve and make connections with other fibers through the various portions of the optic tracts leading to the visual cortex. It is desirable to know, also, something of the physiology of the visual process, e.g., the relative sensitivity of the fovea and periphery to light and color stimulation, the effect of light and dark adaptation upon these functions and the variations that may be induced by diverse conditions.

INDICATIONS FOR VISUAL FIELD STUDIES

It is most important that fields be taken in the following cases:

✓ a. When refractive error alone does not justify the patient's ocular complaint.

RSPHGV
RSVPGH

✓ b. Subnormal vision cases.

✓ c. Manifest or suspected pathology, either localized in the eye or general.

✓ d. Any case with severe headaches and complaints of loss of vision at one side, may be caused by brain tumors.

✓ e. Every case of glaucoma, even when vision is 20/20

f. Before starting a program of vision training, to be sure a Toxic condition is not present & also no scotoma.

g. In every case where livelihood or safety may depend on alert faultless vision, driving, etc

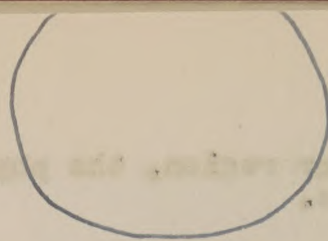
It goes without saying that a careful case history is of utmost importance.

B. Anatomy of the Visual Pathway:

1. Retina:

The manner of distribution of the nerve fibers from the nerve head is an important consideration in the interpretation of the fields. To the nasal side of the disc, above and below, the nerve fibers are distributed in a radial manner; to the temporal side, however, the fibers traverse a greater area to reach the periphery, because they bend around the macular region which is

disc



Horizontal Raphe ~~arising~~ imaginary line extending from fovea.

There is no crossing of fibers over the Raphe - If the fibers are above it they always stay above it.

The fibers tend to be in bundles & not as individual nerve fibers. A defect may affect one entire area or bundle & is referred to as nerve bundle defect

Most of temp edge of disc is taken up by papillo ~~[illegible]~~ macular bundle

Cerebral distribution - centered around fovea - determined by an imaginary vertical line through the fovea. ~~has~~ its origin any retinal nerve fiber which ~~lie~~ nasal to this line is called decussation fibers. They decussate at the chiasm - those that originate on temp. side ~~decussate~~ do not decussate & end in occipital lobe on same side as they originate

Blood Supply - Inner ???? five layers of retina from C.R.A

The behaviors of the colors in an area may determine what type of lesion is present.

Retina attached to choroid firmly at ora serrata & optic disc - but loosely in between & is possible to get ring scotoma this way (also is caused by other things)

supplied by direct nerve fibers from the papillo-macular bundle of the optic nerve.

Extending from the fovea horizontally outwards to the temporal edge of the retina is an invisible line which is not crossed by any nerve fibers and which is known as the horizontal raphe of the retina. It is thus seen that the portion of the retina on the temporal side of a vertical line passing through the papilla contains arching fibers and is divided into upper and lower quadrants by the raphe and an imaginary line continuing it to the disc, while the portion on the nasal side of the papilla line contains radiating fibers and is undivided. The fibers from the upper and lower temporal quadrants constitute the uncrossed bundle which passes to the tract and cortex of its own side. Those from the nasal quadrants form the crossed bundle which crosses at the chiasma and reaches the cortex of the opposite side.

The retina is firmly attached at the disc and at the ora serrata. Between these fixed points, attachment to the underlying choroid is slight. This close attachment at the disc explains to a degree, certain types of ring scotomata.

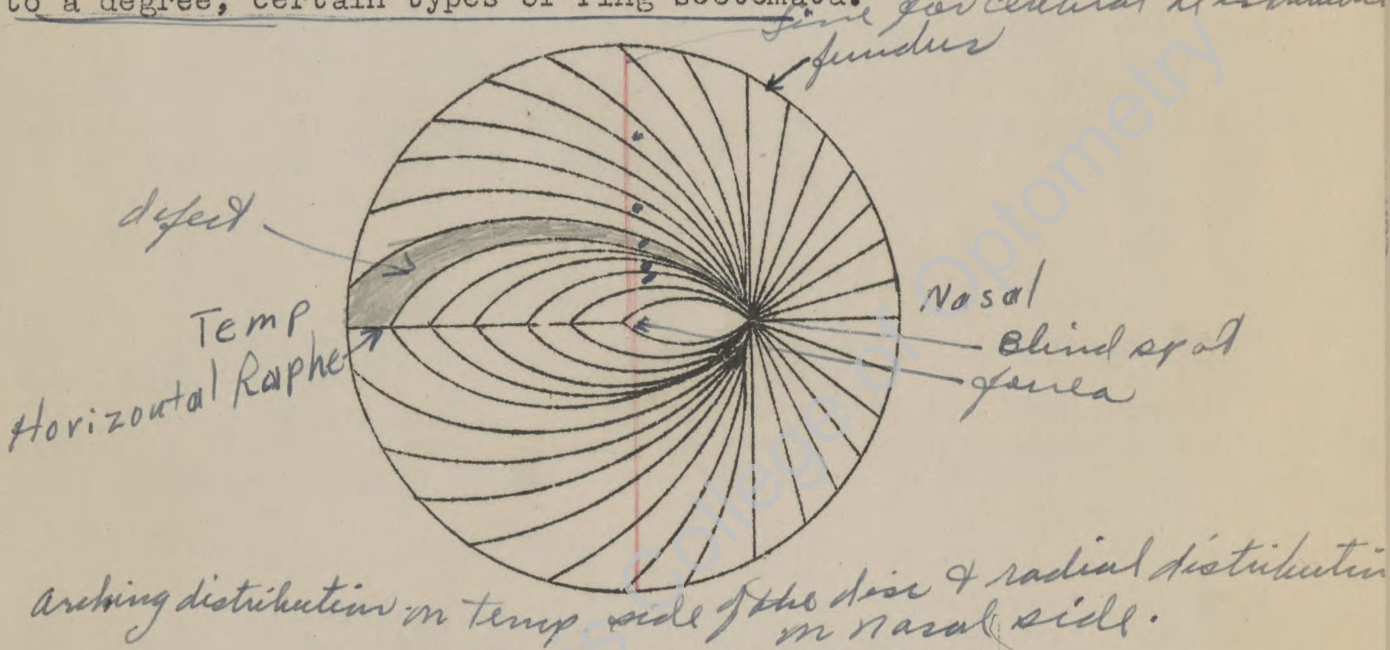


Diagram Illustrating Distribution
of the Retinal Nerve Filaments

2. Optic Nerve:

The optic nerve proper extends from the retina to the chiasm. It is about 5 centimeters long, 3.5 centimeters of which is within the orbit, and 1.5 centimeters within the optic foramen and the skull. Fibers from the temporal region occupy the temporal region in the nerve; those from the upper part of the retina are in the upper part of the nerve.

supplied by direct nerve fibers from the papillo-macular bundle of the optic nerve.

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The retina is firmly attached at the edge and at the ora serrata. Between these fixed points, attachment to the underlying choroid is slight. This close attachment at the disc explains to a degree, certain types of retinal detachments.

Diagram Illustrating Distribution of the Retinal Nerve Fibers.

B. Optic Nerve:

The optic nerve conveys fibers from the retina to the chiasma. It is about 5 centimeters long, 1 millimeter of which is within the sclera, and 3.5 centimeters within the orbit between the sclera and the canal. Fibers from the temporal region occupy the temporal portion in the nerve; those from the upper part of the retina are in the upper part of the nerve.

3. The Chiasm:

According to Weeks, the relation of the crossed to the uncrossed fibers is three to two. The immediate anatomic environment is as important as the chiasm itself. Posterior to and beneath is the pituitary gland which rests in the sella turcica. In the posterior angle is the infundibulum connecting the pituitary with the brain. Directly over the chiasm is the anterior tip of the III ventricle and to either side are the internal carotid arteries. Disturbances of these nearby structures may affect the chiasm.

4. Optic Tracts:

They are formed by the union of the uncrossed fibers of one eye and the crossed fibers of the opposite eye, including the papillo-macular bundle. It passes into the primary optic centers composed of the external geniculate body, the anterior corpus quadrigeminum, and the pulvinar of the thalamus.

5. Paths to the Brain:

Nerve fibers collect from the primary centers and pass through the internal capsule and thereafter spreads into a fan-shaped formation known as the optic radiation. It is generally accepted that a large number of these fibers end in the cortical cells in and about the calcarine fissure.

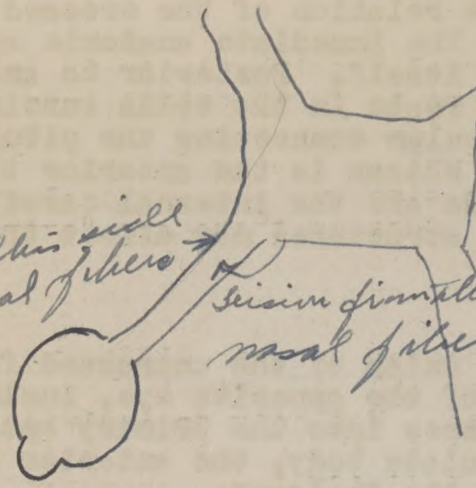
C. Physiologic Principles

1. Central and Indirect Vision:

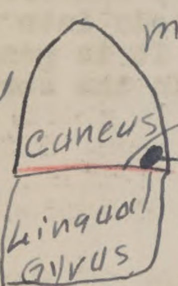
Vision is of two-fold character: (1) central or direct, that which is used in fixation and analysis of a small object, and (2) indirect or peripheral, which makes it possible when central vision is fixed at a small object to observe with considerable detail, objects remotely located from the point of fixation.

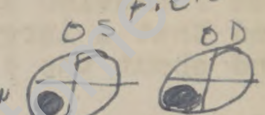
2. Laws of Projection and Direction:

The upper part of the retina receives impressions from the lower part of the field and vice versa; the right half of the retina receives impressions from the left half of the field and the left half from the right field. In perimetry, the defect of the field is recorded and not the location of the lesion. It is necessary to transpose it one wishes to visualize mentally the location of the lesion. *



medial aspect Rt. occipital lobe





Cuneus receives sup. retinal fibers.
Lingual gyrus receives inf. retinal fibers.

A defect post. to chiasm would appear on the opposite side in the visual field.

Nasal field is always more constricted than temporal field.

II. CONSIDERATION OF THE NORMAL FIELDS

If the fields of a group of normal, healthy individuals are plotted and then compared with regard to form, extent, and so on, it will be evident that individual differences and variations exist. This, of course is to be expected just as one would expect to find these same individuals to differ in size, weight, general appearance, intelligence, behavior, etc. Just as there are "extremes" with respect to these latter characteristics, so there are "extremes" with respect to visual fields amoung normal individuals. Consequently, it is important that the examiner become familiar with the variations that may be manifest between different normal individuals so that he may be better able to detect those variations which are of diagnostic significance. Not only do individuals differ among themselves with respect to the character and extent of the visual fields, but the same individual may show variations from time to time. These variations, too, may be considered as normal variations in the normal, healthy individual.

It will be seen, however, that while variations exist among normal, healthy individuals, the relations between the color fields and between the extents of the blind spots remain quite similar. For example, the field for blue is always the largest field, with red next and green the smallest. This sequence is preserved although the absolute size of each field may vary among different individuals. The blind spots are seen to vary relatively little in size, i.e., no suspicious enlargements can be detected.

Largest field of all # is the motion field

green (smallest)
red
blue
form
motion

A. Factors Which Influence the Size and Shape of the Normal Field:

1. Anatomical Factors:

a. Bony conformation of the orbital cavity and the face.

b. Activity of the retina - Greater activity of the extreme peripheral part of the superior and nasal parts of the retina.

c. Width of the palpebral fissure. - only if upper lid droops to ~~sch~~ such an extent that part of pupil is blocked off.

d. Size and plane of pupil.

e - Ametropia

2. Factors in Technique:

a. Intelligence of the patient.

b. Fatigue - Influence of normal fatigue is well marked. Examination should be made when the patient's physical and mental conditions are good, and not at the end of a prolonged general eye examination. Under such conditions the fields obtained will show a contraction

7-15 foot candle power of illumination
10 about most satisfactory -
lumen $= E = \frac{I}{d^2}$

IIFO

which is abnormal for that individual patient. In abnormal functional and organic processes, this factor is of great importance as a type of field is developed which may be regarded as pathognomonic of specific pathologic states.

very impt. & can be controlled

c. Illumination - Form field is not affected in normal conditions to any great extent by slight variations of light. In pathologic states, it has a direct bearing, and in order to obtain uniform results, the best possible light should be used. Color fields are influenced by even slight variations in intensity of illumination.

d. Intensity and character of the stimulus.

e. Pre-exposure and surrounding field.

f. Accuracy of the optometrist.

B. Motion Field:

The extent of the motion field represents the extreme periphery of the retina capable of receiving sensations of motion without recognition of the contours and outlines of a moving object. Clinically the following classification relative to size seems to be sufficient:

Large Motion Fields - in, 50° to 60°; out 70° to 90°

Medium Motion Fields - in, 40° to 50°; out 50° to 70°

The upper and lower extents of the field are naturally restricted in proportion and depend on the width of the palpebral fissure.

C. Form Field:

It is the recognition of the contours and outlines of an object approaching from the periphery toward the fixation mark at the center of a perimetric arc.

It has been established through experimentation that the recognition of white coincides so closely with the recognition of the contours and outlines of an object that the extent of the form field is determined when the patient reports perception of a stationary white target, usually 5 millimeters in diameter.

The following sizes are given:

Large Form Fields - in, 40° to 48°; out, 40° to 50°

Medium Form Fields - in, 15° to 40°; out, 20° to 40°

In normal cases large form fields are to be expected in both eyes.

D. Relative Size of the Color Fields:

The color field represents the area of visual recognition in all directions from the central fixation point of the true saturated color of the target being used while in a stationary position.

The relative size of the color field outlines is entirely an individual reaction. While various authors have presented tables of average sized color fields, so much depends on the technique of the operator, the reaction and special development of the color sense of the patient, that only comparative clinical significance can be claimed for this division of visual field measurements.

The average color fields found by the following authors with a one degree test object are given below:

AUTHOR	TEST OBJECT	COLOR	UP	DOWN	IN	OUT
Peter	1°	blue	26°	38°	35°	54°
		red	21°	28°	27°	41°
		green	18°	22°	23°	26°
Traquair	52' - 5 mm.	blue	30°	33°	35°	80°
		red	22°	21°	23°	53°
		green	12°	12°	14°	28°
Ferree-Rand	1°	blue	35°	42°	43°	62°
		red	32°	40°	40°	60°
		green	22°	25°	26°	38°

Since the figures in the above table are found under ideal laboratory conditions, due allowance should be made for errors which will necessarily creep into the hurried work of a public clinic, especially as studies are made upon patients from all walks of life and in varying degrees of health.

Blue, red, and green in proper rotation without interlacing or overlapping both fields represents normal characteristic color fields.

E. Mariotte's Blind Spot:

The optic nerve head is situated about 15 degrees to the inner side and a little above the horizontal plane of the macula. In the charted field, therefore it is about 15 degrees to the outer side and a little below the center of fixation. It is oval in shape with its long axis vertical. However, the exact shape of the blind spot depends upon the attachment of the choroid and retina.

The inner margin of the average blind spot is 13.5° from central fixation. The blind area is 5 degrees in width and 7 degrees in length, and extends 2 degrees above and 5 degrees below the horizontal meridian. It varies more frequently in normal limits in the vertical diameter than in the horizontal. The distance of the blind spot from the fixation point is increased in hyperopia and decreased in myopia, but the difference is insignificant..

The dimensions given refer to the area of absolute blindness. Surrounding this is a narrow amblyopic zone of about one degree in width in which modified vision is present for white and color. The presence of this indistinct zone is explained by the fact that the retinal outer layer does not terminate abruptly but gradually at the edge of this area.

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The dimensions given refer to the area of absolute blindness. Surrounding this is a narrow amblyopic zone of about one degree in width in which a relative defect is present for white and colors. The presence of this amblyopic zone is explained by the fact that the retinal outer layer does not terminate abruptly but gradually at the edge of this area.

III. Methods of Examination:

Every field examination should begin with a mapping of the peripheral fields on the perimeter. It is customary to begin with a test object of one degree size. However, in cases where the visual acuity is considerably diminished it may be necessary to use larger sized targets. This will give an idea of the type of case one has before him and enable the examiner to plan his examination to best advantage. If any part of the outline suggests a contraction, the outline should then be made with smaller sized test objects. A defect in its early stages may not be demonstrable with the larger test objects but can often be found if smaller test objects are used. By reducing the illumination, even more obscure defects may be shown that would otherwise escape notice.

At least eight major meridians should be examined in every case - superior, temporal, inferior, nasal, inferior-temporal, superior-nasal, superior-temporal, inferior-nasal.

After the test has been carried out to this point, the next step is the examination of the central field by means of the tangent screen or the stereocampimeter. It is usually good technique to plot the extent of the normal blind spot first. By doing so, the examiner can quickly ascertain whether or not the patient is cooperating fully. Futhermore, the patient learns to fixate more steadily and cooperate in a better manner. In many diseases involving the visual apparatus, irrespective of foveal involvement, the blind spots are altered in outline. In some diseases, the type or form of the central defect or the form of the enlarged blind spot is pathognomonic. In other cases, the information is suggestive only and the diagnosis can be made only after other examinations.

Prior to mapping the color fields, a useful bit of information to obtain is the status of the patient's color vision (Ishihara Test, Holmgren Wool Test, etc.).

The most useful methods of field examination may be considered under the following headings:

1. Hand or Confrontation Method.
2. Examination with the Arc Perimeter.
3. Examination with the Tangent Screen or Campimeter.
4. Examination with the Stereo-campimeter.

Whatever method or combination of methods used, the principle of quantitive testing should be adhered to, and the examination should be planned to elicit the intensity of any defect which may be present, as well as its position and extent.

A. Hand or Confrontation Method:

This is the oldest method used and while crude and the results are approximate at best, it nevertheless has a wide range of applicability. The observer's own field is used as a standard for comparison with the field under observation.

The patient is seated in front of and facing the observer, at a distance of about two-thirds meter, or at arm's length. For example, in testing the right eye, the operator covers the left eye with his right hand and asks the patient to fixate his vision on the operator's open or left eye. Then move a white pencil from the extreme periphery midway between the patient and the operator until the patient is conscious of its presence in his indirect vision. This is done in the four cardinal directions, and at other points, if necessary, and the results are compared with the operator's ability to recognize the same object. Using his own field as a standard, any marked cutting or shrinkage in the patient's field may be noted.

This method is not suitable for even approximate color studies. It may be used as a preliminary to a more accurate investigation by other methods.

The hand method may be used under the following conditions:

1. Quick determination of presence of marked contraction.

2. In hemianopsia.

3. Approximate information may be obtained when examining illiterates, feeble-minded people, or people of alien tongue.

4. To take light projection of mature cataract cases using a small light source.

5. When fields are cut to any great extent in chronic glaucoma and central vision reduced by corneal haze.

B. Technique in Arc Perimetry:

General Considerations:

For measuring the peripheral field and mapping of the interlacing and overlapping of the color fields, this method is of sufficient accuracy. With proper illumination and facility with which the test objects may be moved in all meridians, it tends to produce more constant and standard results.

Position of the eye in relation to the perimetric arc and correct fixation are of greatest importance. If the center of the eye does not correspond to the center of the perimetric arc, almost any kind of field may be obtained.

1. Hand or Confrontation Method:

This is the oldest method used and while crude and the results are approximate at best, it nevertheless has a wide range of applicability. The observer's own field is used as a standard for comparison with the field under consideration.

The patient is seated in front of and facing the observer, at a distance of about two-thirds meter, or at arm's length. For example, in testing the right eye, the observer covers the left eye with his right hand and asks the patient to fixate his vision on the operator's open or left eye. Then move a white pencil from the extreme periphery midway between the patient and the operator until the patient is conscious of its presence in the indirect vision. This is done in the four cardinal directions, and at other points, if necessary, and the results are compared with the operator's ability to recognize the same object. Using his own field as a standard, any marked cutting or shrinkage in the patient's field may be noted.

This method is not suitable for even approximate, exact studies. It may be used as a preliminary to a more quantitative investigation by other methods.

The hand method may be used under the following conditions:

1. Quick determination of presence of marked contraction.
2. In hemianopsia.
3. Approximate information may be obtained when examining illiterate, feeble-minded people, or people of alien tongue.
4. To make light projection of mature cataract cases, using a small light source.
5. When fields are not of very great extent in chronic glaucoma and central field defects by central scotoma.

B. Perimetry in the Periphery:

General Considerations:

For a complete the peripheral field and mapping of the periphery and outlining of the outer fields, the patient is of particular necessity. With proper illumination and fixation with which the test object may be moved in all meridians, it tends to produce more constant and improved accuracy.

Position of the eye in relation to the test object and the target fixation are of greatest importance. If the position of the fixation is not maintained by the patient at the correct distance, a normal field may be obtained.

For all standard measurements, a 5 millimeter or one degree color target is the most practical except in special cases where smaller or larger sized test objects are indicated because of the status of visual acuity, etc.

Recognition of most colors as it is moving from the periphery of the arc toward the center is not at first true color recognition.

1. BLUE is first colorless, then a sort of gray, finally blue.

2. RED is first colorless, then sort of terra cotta (yellowish brown), then yellow before it appears red.

3. GREEN is colorless at first, then white before it assumes a really green tint.

One must bear in mind that after the changes given above are duly noted, there is a particular adaptation on the indirect field toward moving objects, and after the eye under examination has registered a perception for a certain color, it will in most cases fade again if the target assumes a stationary position. If colored fields are marked at a point when the color is first perceived, very unsatisfactory results are recorded.

It is well to explain the difference between central and peripheral vision. This can be demonstrated by showing the patient how objects can be seen and recognized when not in line with central or macular vision.

A fixation point of about 3 to 5 millimeters in diameter should be used if the patient's visual acuity is good; if not, a disc large enough to be fairly well seen may be used. Smaller fixation points are not desirable for prolonged use as they tend to blend with the background, owing to the physiological unsteadiness of fixation.

The patient is seated comfortably before the instrument and one eye is occluded. The chin rest is adjusted so that the eye under observation is in alignment with the fixation target at the center of the arc.

Measuring the Motion Field:

With the patient seated properly, a 5 millimeter white target is brought in from the periphery at a moderate and steady rate by a series of short slow zigzig movements across the line of progression. Where the patient first recognizes motion without recognition of the contour or outline of the moving object is the extent of the motion field for that meridian. Test is repeated for all the meridians.

Size makes little difference to a person with normal motion

[illegible] old standard measurements, a 2 millimeter or one-centimeter [illegible] target is the most practical target in general since smaller or larger sized test objects are indicated [illegible] on the status of visual acuity, etc.

Recognition of most colors as it is moving from the periphery [illegible] toward the center is not at first true color recognition.

1. Blue is first colorless, then a sort of gray, finally blue.

2. Red is first colorless, then sort of smoky [illegible] (reddish brown), then yellow before it appears red.

3. Green is colorless at first, then white before it becomes a really green tint.

One must bear in mind that after the response given [illegible], there is a particular [illegible] as the limit of field toward moving objects, and after the eye [illegible] a perception for a certain color, it will [illegible] if the target assumes a stationary position. [illegible] the method of a point when the color is first [illegible] [illegible].

It is well to explain the difference between [illegible] and [illegible]. This can be demonstrated by [illegible] the patient [illegible] with central or [illegible] vision.

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The patient is seated comfortably before the instrument and one eye is occluded. The chin rest is adjusted so that the eye under observation is in alignment with the fixation target at the center of the arc.

Plotting the [illegible] Field:

With the patient seated properly, [illegible] white target is brought in from the periphery [illegible] a series of [illegible] meridians [illegible] where the patient first [illegible] of the [illegible] are recorded [illegible] for all the meridians.

[illegible]

perception. A small target is recommended, preferably 3 millimeters or less. Though it could be seen as part of motion function, the average person, due to lack of training and concentration, will not see it if the target is less than one millimeter when used at the arc perimeter distance of 1/3 meter. A one millimeter target is used in the laboratory. The motion field is recorded in pencil, using short dashes.

Measuring the Form Field:

A one degree white test object is slowly and steadily brought in from the periphery toward the center of the arc until it is first recognized as white. Stop and ask the patient if he still recognizes the target as white while in the stationary position. If the white target had faded immediately following the stopping of the target, move about five degrees further in toward the center and again ask if the white target can be seen as white in the stationary position. If so, the position of the target is recorded properly on the chart. If the target had still faded, it is again moved another five degrees until a point is reached where the patient can maintain white in the stationary position. The phrase "maintaining white" does not necessarily mean holding the color over a long period of time. The form field is recorded in pencil with solid straight lines.

Measuring the Color Fields:

In charting the color fields, blue, red, and green targets of one degree size are used in routine cases. These targets are shown the patient in the paracentral field to acquaint him with the nature of the target. The patient is instructed to call the proper color as soon as he recognizes it. Since the colors go through various stages before the correct color can be recognized while moving in from the extreme periphery, it is well to warn the patient that such a phenomenon will occur. The moment the patient calls out the proper color of the target, the movement is stopped and the patient is asked if he can still see the color. If the color had faded when the movement of the target had ceased, move in about five degrees and again ask whether the color can be recognized while in the stationary position. If he can maintain the proper color for a few seconds, then the position of the target is noted on the chart. Emphasis has been laid in the past regarding saturated colors, but much confusion seems to have arisen due to the fact that the patient does not know exactly when a color is considered to be saturated. Therefore, the recognition of the correct color in the stationary position is to be considered the position of the saturated color. Before attempting to record on the chart, it is recommended that a few trial runs be made to acquaint the patient as to what is required of him. A few minutes extra time spent in carefully explaining the nature of the test will save much time in the long run.

While it is immaterial in what order the colors are presented from the periphery, it is recommended that blue, red, green be presented in that order followed by white for the form field. The order

peripheral. A small target is recommended, preferably 3 millimeters or less. Though it would be seen as part of macular function, the average patient, due to lack of training and concentration, will not see it if the target is less than one millimeter when used at the set patient distance of 1/3 meters. A one millimeter target is used in the laboratory. The motion field is recorded in pencil, using short dashes.

Measuring the Form Fields

A one-degree white test object is slowly and steadily brought in from the periphery toward the center of the arc until it is first recognized as white. Stop and ask the patient if he still recognizes the target as white while in the stationary position. If the white target is lost immediately following the stopping of the target, move about five degrees further in toward the center and again ask if the white target can be seen as white in the stationary position. If so, the position of the target is recorded properly on the chart. If the target was still faded, it is again moved another five degrees until a point is reached where the patient can maintain white in the stationary position. The correct "maintained white" when the [illegible] holding the color over a long period of time. The form fields are recorded in pencil with solid straight lines.

Measuring the Color Fields

In measuring the color fields, blue, red, and green targets of one degree size are used in routine cases. These targets are shown the patient in the peripheral field in conjunction with the nature of the target. The patient is instructed to call the proper color as soon as he recognizes it. Since the colors go through various stages before the correct color can be recognized while moving in from the extreme periphery, it is well to warn the patient that such a phenomenon will occur. The moment the patient calls out the correct color of the target, the movement is stopped and the patient is asked if he can still see the color. If the color has faded when the movement of the target is stopped, move in about five degrees and again ask whether the color can be recognized while in the stationary position. If it can, that is the proper color for the recording, then the position of the target is noted on the chart. [illegible] that the patient does not know exactly which color is considered to be [illegible]. Therefore, the recognition of the correct color in the stationary position is to be considered the position of the [illegible] target. Before attempting to [illegible] on the chart, it is [illegible] the [illegible].

While it is recommended by most people that the colors are recorded [illegible], it is recommended that [illegible] be recorded [illegible] followed by white for the form fields. [illegible]

of presentation of colors must be consistent in all meridians.

It is well to keep the following points in mind:

1. The different test colors must be recognized in the stationary position.

2. The average patient does not know that the red and green fields are narrower than the form or blue fields and very frequently there is a tendency on the part of the patient to answer to soon or to glance from the fixation point to the test object, and thereby cause inaccurate results.

3. Proper measures must be taken to make certain that the patient is not color-blind to one or more of the test colors.

After completing one eye, it is well to wait at least two minutes before continuing with the examination in order to allow the other eye to adapt itself to the level of illumination at the instrument and to the surrounding field.

Because of the possible interlacing of field outlines for different colors, each mark must be identified as belonging to one particular series of marks representing one complete field contour. The simplest method of identification is to use appropriately colored pencils for marking the blue, red, and green limits and an ordinary pencil for the form field limits. To complete the record chart connect each series of points by straight lines of the proper color. It is not desirable to attempt to round out the resulting contours, as that would imply additional points of reference which were not actually charted. Ruled straight lines conform to standard practice.

A dot and line code, all with a black pencil, might be used to differentiate the color fields. A more dramatic method, and one providing easy interpretation at a glance, is to fill in with solid colors the successive fields from the smallest to largest field (Brombach). That is, with a pencil or crayon of the proper color, fill in completely the entire smallest field; with the next color fill in the balance of the next smallest field; with the third color fill in the balance of the third field. Leave the form field uncolored, simply outlined in black. This method reveals easily any overlapping or interlacing of field outlines and conforms to standard practice.

Every record chart should show names of patient and operator, the date and time of day it was completed, the sizes of the test objects used, the test distance, room illumination as well as the illumination reading of the instrument, whether taken with or without Rx, and any other pertinent data. This information is necessary in comparing field studies from different days or different hours of the day.

C. Examination by the Tangent Screen:

1. Campimeter Attachment on Arc Perimeter:

a. Most arc perimeters have tangent screen attachments with charts to fix the attachment. They are small, however, and can be used for only about 25 degrees from the center. They are adequate for central, pericentral, and paracentral scotoma and for the normal blind spot of Mariotte and its enlargements. For peripheral scotoma a tangent screen for use at one meter or one-half meter is necessary. On the Brombach perimeter, the calculated gradations of the chart design eliminate the necessity of altering the observation distance when the shift from perimetry to campimetry is made. On the Ferree-Rand modal, the entire chin rest must be moved out as far as it will go from the center of the arc, and clamped in position.

b. Occlude one eye of the patient and seat him exactly as for the perimeter. A clean record chart is placed on the attachment. The record chart itself serves as screen. For charting blind spots and routine inspection for scotomata, the same chart may be used for both eyes. The physiologic blind spot is charted first. Set the perimeter arc horizontal, and direct the patient to look steadily at the fixation target. The one-half degree white test object on a wand is recommended for poutine charting of the blind spot. Place this test object about ten degrees templeward from the center and ascertain that the patient can see it while looking at the fixation target. Then ask the patient to report when the test object disappears and reappears and move it steadily outward and somewhat downward. When it disappears and farther out reappears, it has traversed the blind area representing the nerve head. This exploratory operation locates approximately the center of the blind area.

c. Once the blind area has been located, a series of points must be established representing its margin. The test object should be moved as nearly as possible at right angles to the boundary. As with conventional perimeter tests, the test object can be moved across the boundary inward until it disappears or outward until it reappears. The two methods must not be mixed, For routine purposes results are probably more reliable by moving the test object always outward, from <u>invisible to visible</u>. Where the patient reports the test object first noticeable, make a mark right on the record chart with

C. Examination of the Central Field:

1. Campimeter Measurement on Arc Perimeter:

a. [illegible]

b. [illegible]

c. [illegible]

[illegible]

the white pencil. Marginal points on the blind spot should be plotted at intervals of not more than 45 degrees around the edge.

d. In mapping the blind spot, particular care should be used to see if there are scotomata starting from the blind spot at any point. For this purpose, the smallest (.17°) test object is recommended. With the smallest test object, circle the blind spot, asking the patient to report if it disappears or seems to fade. Any such report indicates an area that is to be explored and mapped in the same manner as the blind spot.

e. After the blind spot and the area immediately surrounding it have been investigated, a rapid survey should be made of the rest of the field. The easiest and most rapid method is to start from the center of the field and move outward in the direction of the eight major meridians. The patient is asked to report not only when the test object disappears, but also when it seems to fade. In this way many relative scotomata can be detected that otherwise would be missed. Each of these is to be explored in the same manner as for the normal blind spot.

f. A central sctoma will make fixation difficult. If vision is not entirely gone, the patient may be able to gaze steadily at his finger, which he places on the fixation point. In more severe cases, fixation might be established by removing the fixation target and drawing with a white pencil a large + or X in the center of the field. If the ends of the lines overlap sensitive areas, the patient can look at the point where the lines should cross. Or draw a heavy white circle around the fixation point and ask the patient to look steadily at the center of it. Another method is to establish four marks in the field close enough together so that the patient can just see all of them simultaneously when his true fixation is centrally among them. The operator must observe carefully to detect eccentric fixation.

g. Extremely restricted color and form fields can be charted on the tangent screen by the conventional wand method. As the test object is moved steadily toward the center, the patient reports when he surely recognizes the color when the target is in the stationary position.

h. The tangent screen attachments to perimeters are campimeters.

2. Tangent Screen (Gruss, Bjerrum):

a. Tangent screens vary in size depending upon the test distance. In the laboratory are provided one-meter screens. The clinic has a one-half meter screen mounted on a rigid frame. The technique is the same in either case.

b. Seat the patient comfortably at one-meter from the screen (one-meter screen) with the visual axis on line with the central point of fixation. This is accomplished by placing the one meter ribbon which is attached to the screen to the outer canthus of the eye. Occlude one eye. Explain to the patient that the target is not to be followed directly but out of the "corner of his eyes". Place a one-fourth degree white target attached to the end of a wand about ten degrees templeward from the fixation point and ascertain that the patient can see it while looking at the fixation target. Then ask the patient to report when the test object disappears and re-appears and move it steadily outward and somewhat downward. Where the test object is first seen, a black pin is placed as a mark. From here go back along the same line until the target is seen on the nasal side. This is marked in the same way. From here the target is placed within the blind area and moved along the vertical meridian and thus marking the upper and lower limits of the blind spot. The margin of the normal blind spot must be plotted at not more than 45 degree intervals. These points are then transferred to the central fields chart and then connected with straight lines.

c. Having completed the blind spot, we now proceed from the point of fixation out and along each of the various meridians marked on the screen. The patient is told to report any area that becomes the least bit hazy, or if at any time the target cannot be seen, as occurred when mapping the normal blind spot. If any area appears foggy or completely black, a smaller test object should be used and that area outlined as was the normal blind spot. After the abnormal area is mapped with white, colored test objects should be employed over that area.

d. A close search should be made for defects near the fixation area and around the blind spot. The object may be passed several times vertically across the area between these two points to exclude arcuate and caece-central defects. Also, the field immediately above and below the horizontal meridian on the nasal side should be examined to exclude Roenne's nasal step.

D. Examination with the Stereocampimeter:

1. Adjusting the Lloyd Stereocampimeter:

a. Seat the patient comfortably with head in headrest.

b. To map the field of the left eye, attach the campimeter chart on the platform by means of the pins through the holes provided to locate the exact position, so that "LEFT EYE" will show in the upper left-hand corner.

c. Swing the mirror housing to the right (in front of the right eye) until it locks into position.

d. Adjust the side target on the right side arm in the following manner:

(1) Instruct the patient to view the white dot of the fixation target seen with the left eye on the chart board. This white dot is placed directly over the central ring of the pattern on the chart.

(2) Adjust the side target so that the white central fixation ring will appear to be on line, horizontally, with the white dot in the chart board.

(3) Adjust the mirror angle so that the white dot is seen to be in the center of the white ring. Under these conditions the patient will be able to fuse the side target and the chart stereoscopically when the white dot and ring are removed and will have the pupillary distance and any vertical or horizontal phoria compensated for.

e. Adjust the intensity of the lamps with the rheostat dial and turn the rheostat for full illumination.

f. Where the right eye is to be surveyed, follow the same procedure after turning the chart board on the platform so that the legend "RIGHT EYE" will appear at the top on the right-hand side. Swing the mirror housing to the left until it locks into position. Adjust the mirror and side target for stereopsis as above.

In those cases where the patient has no binocular vision and fixes with but one eye, each eye can be examined by covering the other and proceeding as in a monocular examination.

2. Mapping the Fields:

There are various methods in use for the recording of the campimeter fields. Some practitioners prefer to record the fields directly on the chart board. It is recommended that the extent of the various fields not be recorded on the chart board but on a separate campimeter chart. For routine work, the small record card will suffice, while for details, the large duplicate of the chart board is of advantage.

a. In plotting the blind spot, the test object should be moved from "invisible" to "visible", i.e., place test object inside of the patient's blind spot area and move it outward in various directions until the patient reports its appearance. This procedure will insure the determination of the extent of this area. The one-half degree or the one-fourth degree white test object should be used.

   The patient must be instructed as to his part in the test and, no matter how intelligent the patient may seem at first, he invariably turns his eyes to the test object no matter where it may be. It may require a little time and patience to get the idea home to some patients that they are NOT to move their eyes but steadily fixate the negative fixation spot inside of the smallest circle. It is best to outline the blind spot then and discard the first result as it may require a little training to get the patient to cooperate fully.

b. In plotting a color field, the test object (one degree size or larger in cases of low visual acuity) should be shown <u>first</u> in the center and the patient's attention should be directed to its hue and saturation. It should then be removed gradually from the patient's field of vision (while the patient fixates directly ahead on the small central ring) and the patient should be instructed to observe the changes in hue and saturation that take place. The test object is then gradually brought back again and the same changes noted. To measure the extent of the color field, bring the test object from "invisible" to "visible" (periphery to center). The patient should be instructed to signal the examiner (by tapping a pencil on the table) when the test object is seen as having the same color as <u>noted originally in the center</u>. Before testing a new meridian, it is always wise to place the test object for one or two seconds at the central fixation mark so that the patient can refresh his memory as to the true hue and saturation of its color.

c. Scotomata should be investigated with the smaller

2. Reading the Fields:

There are various methods in use for the recording of the campimeter fields. Some practitioners prefer to record the fields directly on the chart board. It is recommended that the contours of the various fields not be recorded on the chart board but on a separate campimeter chart. For routine work, the small record card will suffice; while for details, the large duplicate of the chart board is of advantage.

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The patient must be instructed as to his part in the test and, no matter how intelligent the patient may seem at first, he invariably turns his eyes to the test object no matter where it may be. It may require a little time and patience to get the idea home to some patients that they are NOT to move their eyes but merely locate the negative position spot inside of the smallest circle. It is best to outline the blind spot then and discard the first results as it may require a little training to get the patient to cooperate fully.

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c. Scotomata should be investigated with the smallest

test objects (one-half degree and one-fourth degree). The procedure is similar to that employed in mapping the blind spot. In the case of very small defects at the fixing point, the smallest test objects may be placed in turn at the exact center with the edge turned toward the patient and exposed for a moment and then concealed. This examination should be made with white and colors and, if the defect is found to be (as often it is) a sizeable defect for red and green only and but a minute relative defect for white, larger and larger test objects can be placed at the fixing point and momentarily exposed until the approximate area of the defect for red and green is determined. Thus, for example, in a case of toxic amblyopia when the visual acuity is say, 20/70, one would expect to find a minute defect for white at the fixing point, around which would be a much larger defect for red and around this in turn would be a zone in which green would be called white or yellowish. Larger central defects can be outlined by approaching from the blind spot area if this is also involved (as in toxic amblyopia).

d. Areas where the apparent brightness of the test object is seen to diminish should be investigated most carefully, with small test objects of the colors (relative color scotomata).

e. In order to speed up the examination and avoid fatiguing the patient, the colored test objects may be brought from "invisible" to "visible" rapidly at first and then more slowly as the "true color limit" is approached.

E. General Considerations in Technique of Field Charting:

1. Variable Factors in Technique:

a. Illumination:

Seven foot candles is the most satisfactory degree of illumination for practical clinical work.

b. Surrounding field:

The surrounding field should be a gray of the same brightness as that of the colored stimulus employed. Naturally the gray will be different with each colored stimulus used. If only form fields are being measured, the white test object is exposed on a black background.

c. Pre-exposure:

By pre-exposure is meant the stimulation of the re-

test objects (one-half degree and one-fourth degree). The procedure is similar to that employed in mapping the blind spot. In the case of very small defects at the fixing point, the smallest test objects may be placed in turn at the paper center with the edge turned toward the patient and exposed for a moment and then concealed. This examination should be made with white and colors and, if the defect is found to be (as often it is) a sizable defect for red and green only and but a minute relative defect for white, larger and larger test objects can be placed at the fixing point and momentarily exposed until the approximate area of the defect for red and green is determined. Thus, for example, in a case of toxic amblyopia when the visual acuity is say, 20/70, one would expect to find a minute defect for white at the fixing point, around which would be a much larger defect for red and around this in turn would be a zone in which green would be called white or yellowish. Larger central defects can be outlined by approaching from the blind spot area (if this is also involved (as in toxic amblyopia).

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B. General Considerations in Technique of Field Charting

1. Variable Factors in Charting:

a. Illumination:

Seven foot candles is the least satisfactory degree of illumination for practical clinical work.

b. Surrounding Field:

The surrounding field should be a grey of the same brightness as each of the colored stimulus employed. Naturally the grey will be different with each colored stimulus used. If only form fields are being measured, the white test object is exposed on a black background.

c. Pre-exposure:

By pre-exposure is meant the stimulation of the

tina under investigation by gray of the brightness of the colored stimulus, and for a true and uniform result, such a pre-exposure is necessary.

d. Intensity of the Stimulus:

Intensity depends upon illumination, size of stimulus, hue of color employed, and test distance. The form field may be varied in breadth by increasing or decreasing the size of the test object. Normal color fields are more sensitive to such changes than the form field. The character of the colored pigment is important. Heidleberg papers are recommended as standard colors. Herring pigments are also employed. The former are through and through and do not present a white edge when cut and do not fade.

e. Fixation:

Improper fixation is often directly responsible for the so called interlacing of the color fields.

2. Quantitative and Qualitative Perimetry:

If the peripheral limits of the field show no irregularity by the ordinary stimulus, a gradual reduction in size of the test object is recommended in order to demonstrate the presence of minute changes. To this type of field study the term QUANTITATIVE PERIMETRY is applied. A black tanget screen or perimeter and white test objects of varying sizes suffice, and pre-exposure and surrounding field need not be considered. This method is useful in sharply outlining the dividing line in lateral hemianopsia, and in comparative studies from day to day in progressive or regressive intracerebral conditions involving the chiasm or the visual pathway posterior to the chiasm.

QUALITATIVE PERIMETRY is the more sensitive test involving the use of colored stimuli subtending the proper angle. The intricacies of the qualitative method should be mastered first and employed routinely in field taking and apply the quantitative method to the conditions for which it is adapted.

3. Size of Test Object:

The size of the test object is usually expressed in millimeters in diameter. In order to know the angle subtended, the length of the radius of the instrument must be shown. For all perimetric studies, the size of the test object in millimeters and the length of the radius must always be indicated on the chart. For example, a 5 millimeter stimulus on an instrument of 1000 millimeters radius is written 5/1000.

To convert a stimulus expressed in millimeters into the

line under investigation by means of the brightness of the colored stimulus, and for a true and uniform result, such a pre-exposure is necessary.

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To convert a stimulus expressed in millimeters into the

angle subtended, the following formula, suggested by Traquair, may be used:

$$\frac{S}{R} \times \frac{180^\circ}{\pi} = \text{angle subtended in degrees}$$

S represents the diameter of the stimulus in millimeters; R is the radius of the perimeter in millimeters; π is 3.1416.

Example: To convert a 5 millimeter stimulus used on a perimeter of 33 centimeters or 330 millimeters radius into degrees or minutes:

$$\frac{5}{330} \times \frac{180^\circ}{3.1416} = \frac{900}{1036.7} = .87^\circ \text{or } 52'$$

4. Method of Exposing Stimuli:

In peripheral studies, the test object is passed from the periphery toward the fixation point, or from beyond the visual limits until sensitive retina is reached. If one passes the stimuli in the opposite direction, namely from visibility to invisibility, a larger and incorrect field will be obtained. In studies of the blind spot of Mariotte and of central pathologic scotomata, the stimulus should be passed from <u>blind to sensitive retina</u>. This insures accuracy.

5. Movement of Stimuli:

If the peripheral fields are cut to a considerable degree, and the entire retina is unresponsive to stimulation, it is helpful and correct to impart a vibratory motion to the stimulus to determine the peripheral limits. However, in all studies aside from from movements imparted to the stimulus as just described, the test object should be moved slowly and at sufficient intervals so as not to miss any defect either in the peripheral field or in the central area.

6. Number of Points to be Studied:

There is no hard and fast rule to follow in developing either peripheral limits or central defects. The usual method is to make eight points of study, the cardinal directions and the four points midway between them, but this is insufficient. On a tangent plane the test object is so flexible in its movements that one naturally follows an angular defect automatically. There should be no rule other than that of care. Experience is necessary to give the operator the necessary knowledge as to when it is safe to make studies at wide intervals on the arc.

7. Glasses in Presbyopia and in Defective Vision:

In central field studies the patient may be allowed to wear his correction to which he is accustomed, especially in pres-

byopia and high hyperopia. In peripheral work this rather complicates the examination because an ordinary glass does not admit of extreme peripheral vision to record the true limits of sensitivity of the patient. In high myopia, one runs into difficulty at one-meter because high errors are encountered, but the difficulty is not so great as it might seem to be. When one estimates the loss in central vision in high hyperopia and presbyopia, the reduction does not have so great an effect on peripheral vision as to interfere materially with accurate work. In hyperopia and presbyopia the intensity of the stimulus can be increased by increasing the angle subtended by the test object. In myopia instruments of short radii may be selected, and if necessary, the stimulus can be increased. When practical, however, a suitable correction of the refractive error should be worn.

IV. INSTRUMENTS

A. Perimeter:

1. Purpose:

The instrument was designed for the purpose of plotting the subjective field with constant fixation, for color, form, and motion.

2. Design of Instrument:

Essentially the perimeter consists of a large metal arc of thirty to forty centimeters radius. This arc is supported on a base so that it can be turned about its radius of symmetry as one might turn an umbrella about the axis of its handle, when the handle is in a horizontal direction. Attached to the arc at its center and at right angle is an arm supporting a lamp which turns with the arc.

At the center of rotation and in the center of the arc is placed a round fixation target. The arc is calibrated in degrees from zero at the center to ninety at either end. At the center upon which the arc is described is placed a post which supports a chin rest and over which the eye of the patient fixates the center of the arc. The perimeter is equipped with a small tangential screen for studies of the central area.

B. Tangent Screen (Bjerrum Screen):

1. Purpose:

The tangent screen was designed by von Graefe, Bjerrum, and others for the purpose of plotting the field of view, outlining the projected blind spot, locating scotomata by subjective means--while the patient maintains constant fixation.

2. Design of Instrument:

There are many different types of screens on the market, but they all have a common point in that they are screens perpendicular to the line of fixation, or tangent to the arc of the perimeter which would have the same radius as the distance to the screen. Some are small with only a short distance between the patient's eye and screen and so are portable. Others are of compararively large dimensions and are hung or fastened to the wall while the patient is one or two meters away. Some are of slate color, others black, and others made of transparent material through which a small spot of light is visible.

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There are many different types of screens on the market, but they all have a common point in that they are screens perpendicular to the line of fixation, or tangent to the arc of the perimeter which would have the same radius as the distance to the screen. Some are small with only a short distance between the patient's eye and screen and so are portable. Others are of comparatively large dimensions and are hung on the wall which the patient is one or two meters away. Some are of white cloth, others black, and others made of translucent material through which a small spot of light is visible.

C. Llyod's Stereo-campimeter:

1. Purpose:

The stereo-campimeter is used for making para-central and central field studies with binocular fixation or with monocular fixation when necessary.

2. Design of Instrument:

It is essentially a stereoscopic scotometer. In the new modals, a front surface mirror is enclosed in a housing which acts as a field stop against distracting stimuli and permits the patient to view only the side targets. By rotating this mirror, the fixation target from either side arm may be brought into proper viewing position. This target is then fused with the corresponding fixation pattern on the chart which is on a platform directly in front of the eye under test. All adjustments for any interpupillary distance or phoria are accomplished by means of the mirror and side targets.

*D. Construction of a Bjerrum Screen:

The screen consists of a square of black felt, as free as possible from seams or markings, mounted on a roller or stretched upon a fixed frame light enough to be easily moved. The dimensions should be approximately 2 meters high and 2½ meters wide. The fixation point may consist of a disc of matt white paper or cardboard attached by a black headed pin to the center of the screen. The advantage of this type of fixation is that it is possible to use various size fixation points from three millimeters to four millimeters upwards. Buttons of four to six millimeter size may be sewed on.

There are two methods that may be employed in marking reference lines on the screen. Horizontal and vertical lines may be marked on the screen at 10 centimeters intervals, and thus the screen will have the appearance of a coordinate paper marked in 10 centimeter squares.

The other method consists of using polar coordinates instead of rectangular coordinate systems just described. In this case radial lines are drawn through the point of fixation at 45 degree intervals from zero to 360 degrees. With the fixation point as a center, circles are drawn in 10 degree intervals until the limit of the screen is reached.

In order to lay out the circles on the screen, the length of the screen radius (distance from screen to patient) must be decided upon. This radius may be either one meter or two meters, depending upon the available space. In order to find the radii in millimeters of the 10, 20, 30 degree reference circles, one multiplies the natural tangent of these angles by 1000 millimeters; if the patient is to be placed two meters from the screen, multiply

C. Lloyd's Stereo-campimeter.

1. Purpose:

The stereo-campimeter is used for making para-central and central field studies with binocular fixation or with monocular fixation when necessary.

2. Design of Instrument:

It is essentially a stereoscopic stereoscope. In the new models, a front surface mirror is enclosed in a housing which acts as a field stop against distracting stimuli and permits the patient to view only the side targets. By rotating this mirror, the fixation target from either side arm may be brought into proper viewing position. This target is then fused with the corresponding fixation pattern on the chart which is on a platform directly in front of the eye under test. All adjustments for any interpupillary distance or phoria are accomplished by means of the mirror and side targets.

D. Construction of a Bjerrum Screen.

The screen consists of a square of black felt, as free as possible from seams or patches, mounted on a roller or stretched upon a fixed frame light enough to be easily moved. The dimensions should be approximately 2 meters high and 2½ meters wide. The fixation point may consist of a disc of matt white paper or cardboard attached by a black headed pin to the center of the screen. The advantage of this type of fixation is that it is possible to use various size fixation points from three millimeters to four millimeters upwards. Buttons of four to six millimeter size may be sewed on.

There are two methods that may be employed in marking reference lines on the screen. Horizontal and vertical lines may be marked on the screen at 10 centimeters intervals, and thus the screen will have the appearance of a coordinate paper marked in 10 centimeter squares.

The other method consists of using polar coordinates instead of rectangular coordinate systems just described. In this case radial lines are drawn through the point of fixation at 30 degree intervals from zero to 360 degrees. Using the fixation point as a center, circles are drawn at 10 degree intervals until the limit of the screen is reached.

In order to lay out the circles on the screen the length of the screen radius (distance from screen to patient) must be decided upon. This radius may be either one meter or two meters, depending upon the available space. In order to find the radii in millimeters of the 10, 20, 30 degree reference circles, one multiplies the natural tangent of these angles by 1000 millimeters if the patient is to be placed one meter from the screen, multi-

by 2000. In all cases the reference lines should be made as inconspicuous as possible. Perhaps the best method is to stitch these lines in dark blue thread. This will give fairly indistinct lines as a guide to the operator and is not suggestive to the patient.

The blind spots are more difficult to place correctly. The average blind spot for a one meter radius measures 89 millimeters horizontally, and 122 millimeters in the vertical diameter. The upper margin is 37 millimeters above the horizontal line which passes through the point of fixation. From the point of fixation to the inner edge of the blind spot on the horizontal line the distance is 232 millimeters, and to the outer edge the distance is 321 millimeters. With these points definitely fixed, the ellipsoid may be outlined free-hand and then stitched with blue thread.

The location of the blind spot for a two meter radius is as follows: The inner edge is 460 millimeters and the outer edge is 632 millimeters from the point of fixation; the upper edge is 80 millimeters above the horizontal line and the lower edge is 170 millimeters below the horizontal. With these points located, the blind spots can be outlined free-hand.

V. Visual Field Analysis:

The most important and possibly the most difficult part of the entire visual field technique is the analysis of the findings. It requires considerable practical clinical experience to interpret the results of investigation into the peculiarities of the indirect field of vision. Regardless of how precisely the measurements have been made, a great deal depends upon the cooperation of the patient and the training and skill of the operator. At best, it is a subjective test and only records the reaction of the patient to the manner in which a stimulus has been offered. Like all biological tests, mathematical precision in results is not to be expected.

Emphasis must be laid upon the fact that visual fields alone do not constitute an independent diagnosis. They represent nothing else but the mental and physical reaction of the patient to certain stimuli at the time the test is made. Therefore it is highly improbable to find a typical field for a definite pathology.

Field defects are usually the result of interference due to lesions or pressure at some point along the retino-cerebral pathway. Some of the many conditions known to produce field alterations or losses are: Glaucoma, brain tumors and abscesses, lesions of the thalamus and visual cortex, pituitary disturbances, circulatory and glandular disturbances, choroidio-retinal diseases, diseases of the optic nerve, path, and tract, toxemias, anemias, dental pathology, traumatisms and vascular accidents, refractive anomalies, etc.

Field defects may be classified in the following manner:

1. Constrictions or contractions of motion, form, or color fields.

   Interlacing or inversion of order, or color fields.

2. Blind spot enlargements - Seidel's sign; Bjerrum's sign; Roenne's nasal step; transitory visual aphasia; etc.

3. Scotomata:

a. Positive	e. Absolute	i. Peripheral
b. Negative	f. Indistinct	j. Unilateral
c. Relative	g. Central	k. Bilateral
d. Ring	h. Paracentral	l. Symmetrical

4. Hemianopsias (Altitudinal and vertical)

   a. Homonymous
   b. Heteronymous

5. Pathological fields.

6. Sector defects

    a. Quadrantic or partial quadrantic
    b. Hemichromatopsia

7. Mental fields

A. Constrictions or Contractions of Motion, Form, or Color Fields. Interlacing or Inversion of the Color Fields.

1. Motion Field Changes:

Medium Motion Fields --------- Indicative of pathology if control tests made at intervals show a gradual restriction. If no changes occur and in the absence of other clinical symptoms, may be considered tentatively normal.

✓ Small Motion Fields ---------- Always result of pathology. If fundus is negative, the case should be referred without delay to the ophthalmologist.

Right Large with Left Small -- May be due to lesion posterior to the left bulbus (bulbus oculi) and anterior to the chiasm if fundus is negative.

Right Small with Left Large -- May be lesion posterior to right bulbus and anterior to the chiasm if fundus examination is negative.

✓ Motion perception may be lost in trauma following head injury.

The ability to recognize moving objects may be entirely destroyed without any impairment of the ability to see form, line, and color. Cases of this type are often associated with left or right anesthesia.

The sense of motion although closely associated with macular perception appears to be able to function even though central vision is impaired or destroyed.

2. Form Field Changes:

Medium Form Fields:

May be considered normal if they are restricted in direct relationship with motion fields. If changes in the medium size of the form fields occur with motion fields unimpaired, they must be considered indicative of abnormality; or in some cases, visual fatigue to the state of creating an exhaustion.

Small Form Fields:

Are positive indications of focal infections (locked infections) if no changes occur with comparative tests and the motion fields are unimpaired. Alveolar abcesses and residual infections developing in parts of the gum formerly occupied by a devitalized tooth are the most frequent causes for this field phenomena. Cases of chronic appendicitis, ovarian cysts, and similar pathology may be the causative factors. If the etiological factor is eliminated, the collapsed form fields will become normal within a few days. This is particularly true in cases of locked infections of the dental region. In focal infections the form fields will remain small regardless of how many comparative tests are being made. Usually symptoms of ocular asthenopia, fronto-basal and occipital headaches, conjunctival infiltration, neuritis, and a low tonus of the various ductions without any material change during comparative tests, are recorded. Visual comfort is rarely enjoyed regardless how efficiently ametropia has been corrected. Orthoptics are without value. Cases, if neglected, may develop iritis, glaucoma and other pathology of the eye and may be directly responsible for permanent damage to vision. Ocular relief should be restricted to correction of ametropia when necessary during the investigation. Invariably, ophthalmic correction prescribed during the activity of the toxic agent has to be altered after the elimination of the pathology. As the causative factor is eliminated, the form field will resume normal size within a few days. It is interesting to note that the tonus of the ductions will improve in direct harmony with the recovery of the size of the form field.

Right Field Large With Left Field Small:

Visual fields indicating form field collapse in one eye. This field phenomenon is rarely found early in the morning except among night workers. Results of investigations over a period of more than seven years have established the fact that these form field collapses in one eye are associated with physical or mental exhaustion. In case of a collapsed motion field due to injury posterior to the left bulbus and anterior to the chiasm, the form field will show the same relative collapse.

Reduced Form Fields Without Any Color Abnormality may indicate an interference in the visual processes, probably a fatigue. Usually more prevalent in the afternoon hours, but it may be present in the morning as well, same as other visual fatigues may give rise to symptoms in the early hours of the morning. Eliminating the source of interference will cause the fields to return to normal in this instance just as if it were a toxic source of interference and were eliminated. If reduction of the form field is present in the evening only, then some factor during the day has induced the state of exhaustion. If so, the contributing factor must be eliminated. Common among such causes is improper lighting, small and indistinct print or other working material, visual fatigue from special vocational working environments, remaining at one task for long periods without change of the visual task or relaxation, or a simple visual interference that becomes intensified during the

Small Form Fields:

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Reduced form fields without any color abnormality may indicate an interference in the visual pathways, probably a fatigue. Usually more prevalent in the afternoon hours, but it may be present in the morning as well, same as when visual failures may give rise to symptoms in the early hours of the morning. Eliminating the source of interference will cause the fields to return to normal in this instance just as well as when a major factor of interference has been eliminated. If reduction of the form field is present in the morning only, have your patient relate if he has incurred the sight of exhaustion. If so, this possibility, however, must be eliminated. Improper diet, weak tissues, small and indistinct print on glossy surfaces, reflected glare, improper vocational lighting environments, persisting in reading for long periods without change of the eyes, and a similar visual task, all tend to cause fatigue.

working day.

There is another problem causing reduced form fields without color deviations from the characteristic perception and that is from the common ailment we miscall "eye-strain". An interference in the normal process of performing visual skills very often produces this reduced form area, and usually one eye is more advanced than the other. When the source of interference is removed, there will be an enlargement of the form field and a change from interlacement with color outlines. Visual fields themselves do not contribute much to diagnosis of such a problem but rather offer confirmation, and rule out other possibilities.

3. Toxic Fields:

a. The interlacing and inversion of color field outlines are the analytical factors which represent the basis for a proper interpretation and classification of the various stages of intoxication.

b. The disturbance of function caused by the activity of poisons is termed intoxication. Intoxication, then, is a condition of poisoning, or rendering toxic, and has a much broader meaning than that ordinarily applied in relation to inebriety from alcohol intoxication. A clear understanding of this will be necessary as we refer so frequently to intoxication in its true meaning.

c. There is no given amount of any toxic substance that will produce a given stage of intoxication. The terms stimulative and depressive are derived wholly from the effect upon not only the visual field but upon other functions in the organism. Some of those that have been specifically correlated with field changes are ductions, cardiac rate, respiration rate, and sensations experienced by patients while under controlled influence of drugs in the various stages. It has been found that when these supplementarily tested functions have exhibited a state of stimulation, or a state of greater irritability, the fields are increased in size and certain proportions, and interlacings and overlappings of colors are manifested. When all functions tested are impeded in their activity and are in a state of depression other field phenomena are manifested.

d. When toxic substances are created in the body, or taken into the body, they are circulated in the blood stream. Just exactly how the toxins in the blood affect the areas of vision for some colors is not known. Toxins circulating in the blood stream will be eliminated in a very short time. If the source of production is stopped the complete elimination will be effected in a very short period. Because the kidneys, skin, lymph nodes, etc., withdraw toxins from day to day, or from morning until evening. Then if we take visual fields in the morning after the patient has had rest and has not been taking poisons into his system for several hours, and find a normal field, but late in the day we find a toxic

varying day.

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field, we assume that something taken into the body during the day has been toxic to that person. On the other hand, if we find the same toxic picture morning and evening, we assume that the toxic source is inside the body, producing the poisons at night as well as in the daytime. If the fields are normal morning and evening, we assume the person has sufficient resistance to any toxic substance that he may harbor so that it creates no interference in his visual makeup.

e. Toxic conditions arising internally are termed endogenous (endo - inside; genesis - origin) and toxic conditions arising from outside the body but taken into it are termed exogenous (exo - out; genesis - origin). In this differentiation we have a very valuable aid in the diagnosing of toxic sources. The endogenous toxemias may need other professional care. Those that are exogenous often can be found by the elimination method of taking control tests with all potential toxic agents until the responsible one is found.

f. Clinical results obtained by eliminating and controlling certain improper hygienic habits or factors, and poisoning due to unorganized bodies introduced from without, have been productive in the recognition of three definite stages on intoxication, affecting the color fields in a specific and distinct manner. The three stages of intoxication are:

(1) Stimulative
(2) Depressive
(3) Degenerative, or amblyopic stage

g. Intoxication, Stimulative Stage:

(1) If normal in the morning with restful sleep, and charts made at a later hour show an interlacing effect of green over red, together with a general increase of the entire field, the presence of stimulative intoxication is indicated.

(2) Maximum range of stimulation is reached as indicated by complete reversal or inversion of the green color field outline over the red. It represents the greatest expansion of the entire field and highest degree of stimulus of the various ductions in a given case.

CAUSATIVE AGENTS

Tobacco
Coffee
Tea
Chocolate
Alcohol
Atropin

Aspirin
Quinine, and other alkaloids
Cosmetics
Electrotherapy
Glandular therapy and other
stimulative treatments
Ametropia
Heterophoria
Asthenopia
Abnormal lighting conditions
Overwork, and other improper
hygienic habits

RULES FOR DIFFERENTIAL ANALYSIS OF INTOXICATION:

1. Color field analysis will not present a definite clue as to the nature of the specific causative agent of any type of temporary intoxication in the first test made.

2. If the presence of a type of temporary intoxication has been established, advise your patient to refrain from using any of the potential causative agents for a period of 24 hours.

3. If the field assumes normal color field perception and if the relative size of the field is in harmony with the relative stimulus of the ductions, the field is termed toxin free.

4. If you suspect that tobacco is the potential cause, advise your patient to eliminate tobacco for 24 hours but instruct him to take his customary amount of all toxic agents eliminated during the first day test.

5. If tobacco is the causative agent, then the characteristic color field perception and the relative size of the field will be negative.

6. This process of elimination must be continued until the real cause has been eliminated.

7. It is not necessary in most cases of coffee or any other causative agent to insist on entire elimination. Tests may be continued to establish tolerance.

See PLATE 1 showing an example of fields for Intoxication, stimulative stage.

h. Intoxication, Depressive Stage:

(1) Color fields show a tendency toward contraction. One eye usually manifests a more rapid collapse of the entire field, with a definite interlacing effect of the red field outlines over blue,

PLATE 1

Mr. W. S., high school student, age 17.
Fundus non-pathologic, vision O.U. 20/20; static retinoscopy O.U. plus .37 sphere, dynamic O.U. plus 1.25 sphere.

Complains of having inflamed eye for about a year. Has been under medical care for several months for nervous disorders. Frontal headaches appear periodically late in the afternoon. His physician advised elimination of cigarette smoking without obtaining cooperation of the boy.

COLOR FIELDS

Figure 1 taken September 11, 1928 at 9:15 A.M. Characteristic color field perception and relative size of field normal.

Figure 2 taken September 11, 1928 at 9:25 A.M. Field normal; adduction 24/14; abduction 5/4; esophoria 1; positive reserve at near 28/22; negative reserve 20/16; exophoria 6. Patient was instructed to appear for a comparative test, within a few days during the afternoon hours.

Figure 3 taken September 13, 1928 at 3:00 P.M. Complete inversion of green over red, relative size of field normal.

Figure 4 taken September 13, 1928 at 3:40 P.M. Complete inversion of green over red, relative size of field normal. Adduction 30/25; abduction 8/6; esophoria 1; positive reserve 36/27; negative reserve 24/22; exophoria 8. Patient admits of averaging 10 cigarettes per day, does not use more than one cup of coffee daily. He was advised not to smoke for a period of 24 hours and report.

Figure 5 taken September 14, 1928 at 3:40 P.M. Characteristic color field perception and relative size of field normal.

Figure 6 taken September 14, 1928 at 3:30 P.M. Field normal.

Figures 1 and 2 taken in early forenoon are normal and the visual survey is negative. The comparative tests made two days later established the presence of an exogenous toxemia. Tobacco was considered the most probable causative. The boy was informed that if this change in the color field was due to his smoking, the charts, represented by figures 3 and 4 showing the maximum stage of intoxication, would reassume a normal relationship providing he would abstain from cigarette smoking for 24 hours. This was done and figures 5 and 6 established the etiology. Reports from his parents indicate the desired results were obtained. His discomforts disappeared within a few days.

Legend: Blue Red Green

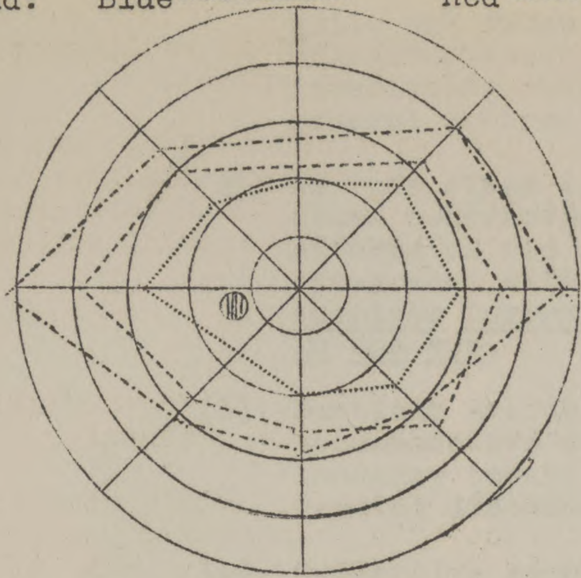

Fig. 1 O.S.

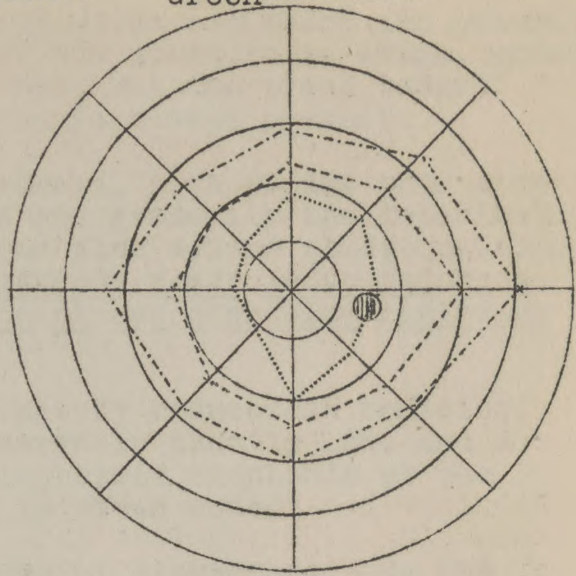

Fig. 2 O.D.

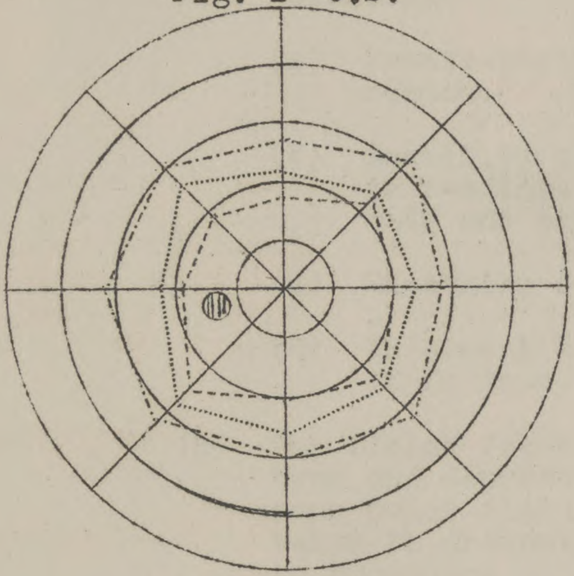

Fig. 3 O.S.

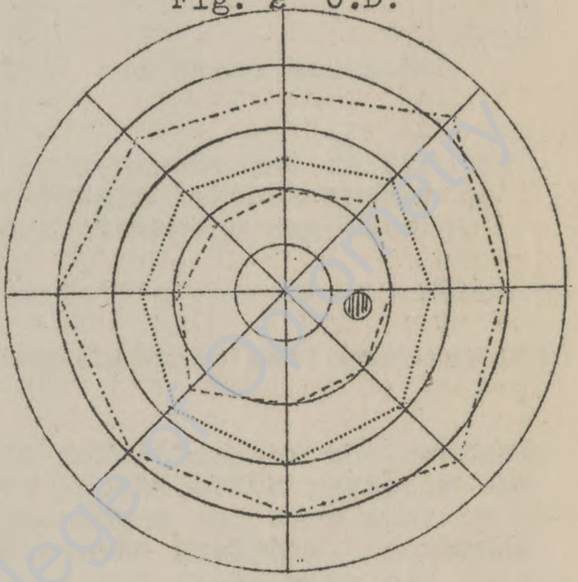

Fig. 4 O.D.

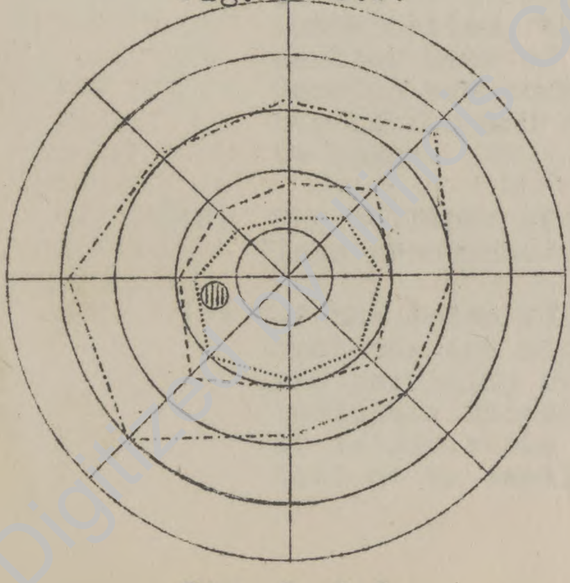

Fig. 5 O.S.

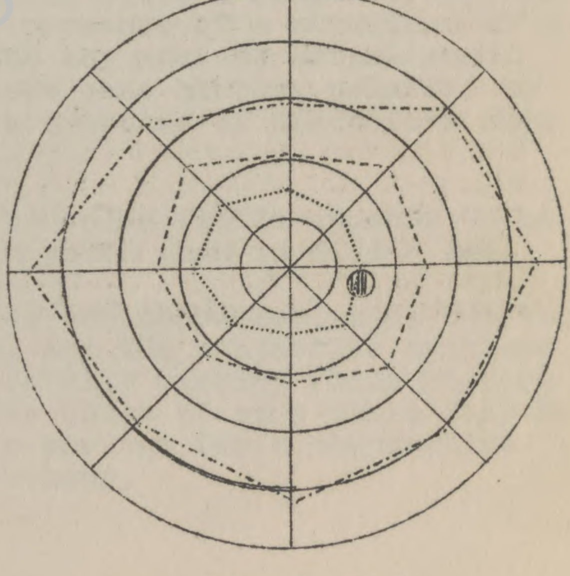

Fig. 6 O.D.

while the other eye often registers the peculiar characteristics of the stimulative stage, green interlacing with red, but the trend toward general contraction is always present.

(2) As this stage advances, both fields show a decided contraction and gradually the interlacing effects of red over blue assume almost uniform appearance with <u>maximum range indicated by a complete inversion of red over blue registers in one eye</u>.

(3) Ductions are definitely reduced in tonicity, accommodative reserve is usually low, and a tendency toward increased exophoria at the reading distance is often noted.

(4) Subjective symptoms of discomfort show the following:

  (a) Fronto-occipital and basal headaches common.

  (b) Inability to concentrate and difficulty in reading. Certain letters appear to fade and others disappear completely.

  (c) Encounter a variety of nervous symptoms.

  (d) In almost every instance patients complain of fatique.

(5) The fields found in infections of the drainage type and depressive intoxication register the same color field phenomena and care must be taken to prevent mistaken analysis. In order to pronounce a restricted field with red interlacing or overlapping blue, a stage of depressive intoxication, the presence of a stimulant at an earlier hour of the day must be established. Careful and complete case history relative to his habits and his symptoms of discomfort must be taken.

(6) The collapse of the color fields appears to be less pronounced in youth than in middle age.

(7) If the color fields are characteristic, but the ductions are high, and the subjective symptoms are partially or totally missing while history indicates excessive usage of some toxic factor, it is advisable to arrange for a comparative test at an earlier hour.

See PLATE 2 showing an example of fields for Intoxication, depressive stage.

i. Intoxication, Degenerative or Amblyopic Stage:

Toxic amblyopia, retrobulbar neuritis, and axial neuritis are used as interchangeable titles, for conditions which, in main, are lesions of the optic nerve.

The principal perimetric indication is a central scotoma. This may be classified at first as a relative central scotoma for green but often develops into an absolute central, sometimes paracentral type and is often positive. In every case one eye shows the defect first, while the other registers the effects found in depressive intoxication.

The relative size is generally depressed, particularly the fields of patients of middle or advanced age.

Clinical experience indicates that the eye which shows the symptoms of depression will invariably develop the first symptoms of the relative scotoma for green, and effect red and blue next before registering an absolute scotoma.

The field of the other eye shows red over blue interlacing with a general degenerative change of the field, and according to the severity of the intoxication, may or may not develop into the degenerative stage.

The visual acuity in a case of relative central scotoma varies between 20/80 to 20/200.

See PLATE 3 showing examples of fields for Intoxication, degenerative stage.

GENERAL CONCLUSIONS OF DIAGNOSTIC VALUE:

1. Color field and duction and analysis must be made at different hours of the day.

2. If the introduction of a toxic agent from without is eliminated, a seven to eight hour sleep will indicate a negative color field.

3. Patients working at night or arising early, may present the various forms of intoxication, even of the advanced stages in the forenoon.

4. There is no typical color field for a specific type of in-

PLATE 2

Mr. R. McC., age 35; occupation none.
Fundus normal; vision 20/20; Rx O.U. .25 cylinder axis 90.

COLOR FIELDS

Figures 1 and 2, both eyes, taken 10:30 and 10:45 A.M. on August 17, 1926.

Characteristic of color field perception normal. Relative size of field small; adduction 8/4; abduction 3/2.

Figure 3; left eye taken on August 17, 1926 at 4:45 P.M. Characteristic of color field perception, red overlapping and interlacing with blue. Relative size of field medium; adduction 2/1; abduction 2/1 at 13 inches; positive reserve fusion 3/2; negative reserve fusion 2/2; exophoria at 13 inches 4; amplitude of accommodation 2.50 D. Patient complains of occipital and basal headaches, vertigo, insomnia, and inability to do any work demanding concentration. He indulges in alcoholic beverages and averages 3 cups of coffee between 9:00 and 10:00 A.M. He has consulted various nerve specialists in Europe without obtaining satisfactory relief. He was instructed to refrain from coffee for a period of 24 hours.

Figure 4; left eye, taken on August 18, 1926 at 4:45 P.M. Characteristic of color field perception normal. Relative size of field small. No change in the phorometric analysis. He was instructed to drink one cup of coffee in the morning for two successive days.

Figure 5; left eye, taken on August 20, 1926 at 4:45 P.M. Characteristic of color field perception shows slight interlacing of green with red. Relative size of field medium; adduction 16/10; abduction 5/4; positive reserve fusion 20/12; negative reserve fusion 10/7; amplitude of accommodation 3.50 D.

He was then advised to refrain from consuming coffee entirely and report within 13 days.

Figure 6; left eye, taken on September 2, 1926 at 4:25 P.M. Characteristic of color field perception normal; relative size of field large; adduction 18/16; abduction 6/5; positive reserve fusion 26/20; negative reserve fusion 16/14; amplitude of accommodation 3.50 D. Symptoms of discomfort had entirely disappeared. Case discharged with the hygienic advice to refrain from the usage of coffee.

PLATE 2

Legend: Blue - · - · - · - Red - - - - - - - Green · · · · · · · ·

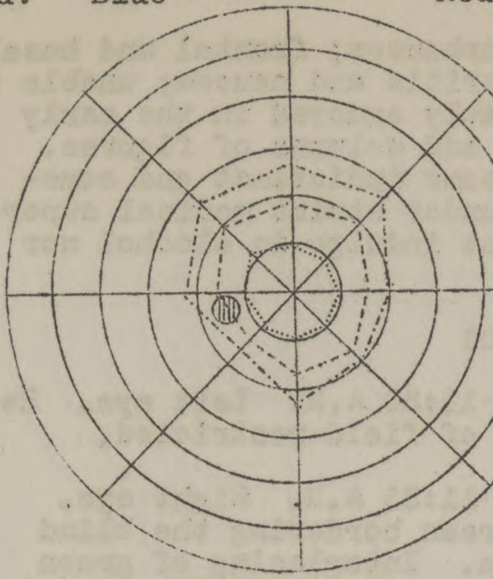

Fig. 1 O.S.

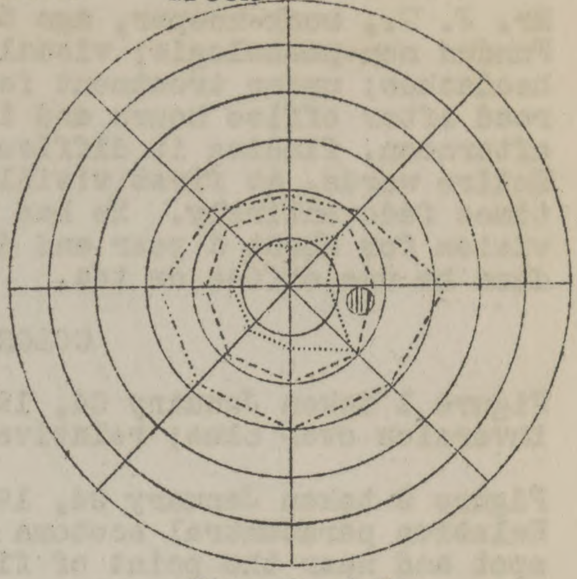

Fig. 2 O.D.

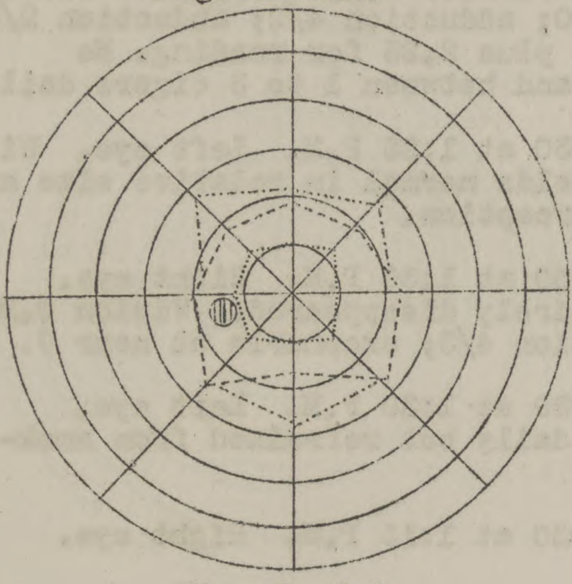

Fig. 3 O.S.

Fig. 4 O.D.

Fig. 5 O.S.

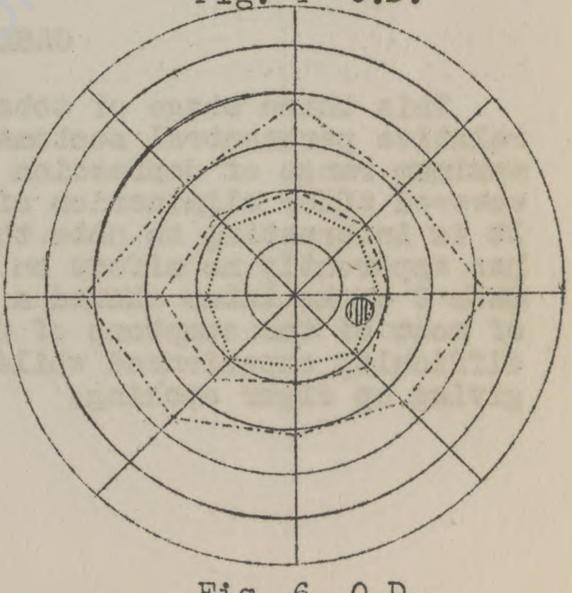

Fig. 6 O.D.

PLATE 3.

Mr. J. W., book-keeper, age 52.
Fundus non-pathologic; visual disturbances; frontal and basal headaches; under treatment for gastritis and nausea; unable to read after office hours and is greatly annoyed in the early afternoon, finding it difficult to add columns of figures. Entire words, at first visible, become indistinct and sometimes fade entirely. He has been under strict medical supervision for about a year and does not indulge in alcohol nor does he use coffee or tea.

COLOR FIELDS

Figure 1 taken January 24, 1930 at 11:50 A.M. Left eye. Red inversion over blue; relative size of field restricted.

Figure 2 taken January 24, 1930 at 11:35 A.M. Right eye. Relative paracentral scotoma for green bordering the blind spot and near the point of fixation. Interlacing of green over red and red over blue. Relative size of field restricted. Vision O.D. 20/100, O.S. 20/30; adduction 4/2; abduction 2/0; exophoria at near 12; Rx O.U. plus 2.25 for reading. He averages 15 to 20 cigarettes and between 1 to 3 cigars daily.

Figure 3 taken January 27, 1930 at 1:25 P.M. Left eye. Without smoking for 24 hours. Fields normal in relative size and characteristic color field perception.

Figure 4 taken January 27, 1930 at 1:30 P.M. Right eye. Field normal; scotoma had entirely disappeared. Vision O.D. 20/30; adduction 12/8; abduction 4/3; exophoria at near 9.

Figure 5 taken January 29, 1930 at 1:30 P.M. Left eye. Patient smoked 15 cigarettes daily but refrained from smoking cigars. Field normal.

Figure 6 taken January 29, 1930 at 1:15 P.M. Right eye. Field normal.

CASE ANALYSIS

This third stage of tobacco intoxication producing a relative paracentral scotoma for green in the right and the maximum range of depression intoxication in the left eye recovered after elimination of the small number of cigars used. It is interesting to note that the smoking of 15 cigarettes has apparently no effect on the fields. A comparative test made 6 weeks later showed a negative field and a disappearance of most of the symptoms of discomfort. The headaches and the difficulty experienced while reading did not re-occur after giving up cigar smoking.

PLATE 3

Legend: Blue ·-·-·-·-·-· Red - - - - - - - - Green ··············

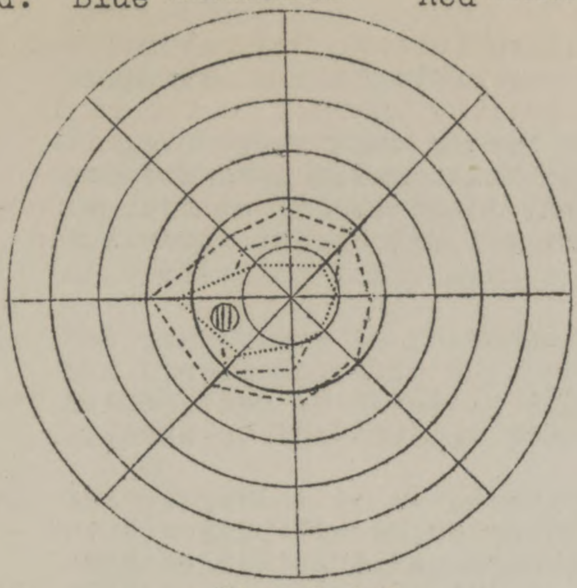

Fig. 1 O.S.

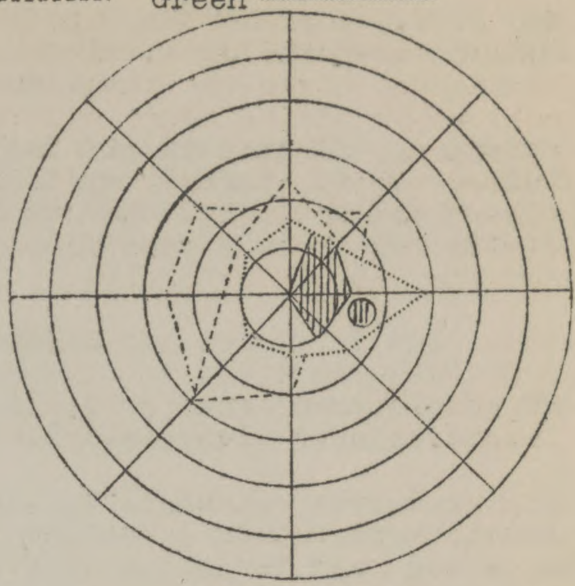

Fig. 2 O.D.

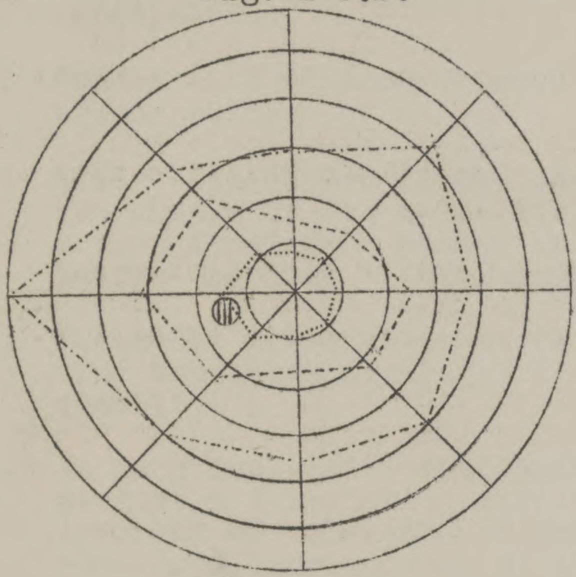

Fig. 3 O.S.

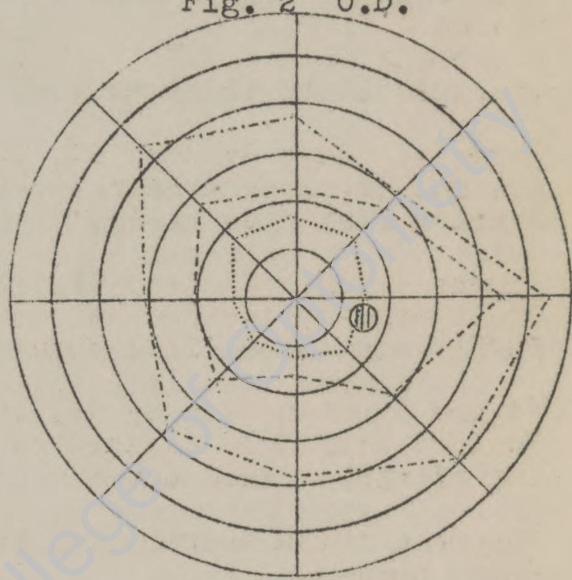

Fig. 4 O.D.

Fig. 5 O.S.

Fig. 6 O.D.

toxication; the effects of color field perception and the relative size of the field in tobacco and coffee, and other causative toxic agents are similar.

5. It is obvious that before final conclusions for or against contemplated measures of relief are formed, it is of vital importance to ascertain whether functional results recorded are exaggerated, diminished, or neutralized by the effects of irritating toxic agents.

6. The variations in response during the course of the corrective treatment, also the permanence of the final results obtained, can be directly explained in many instances by the effects of the various forms of temporary intoxication.

7. The variation in recording visual acuity at different hours of the day, for which there appears to be no pathological explanation as determined by exploration of the fundus, may depend or may be associated with some stage of temporary intoxication.

8. Fundus explorations in most cases of temporary intoxication are negative.

9. After elimination of the causative toxic agent or factor, the change of the color field to normal will take place in a very consistent manner from the depressive to the stimulative and then to the normal field.

10. The color field will not resume normal perception until the true causative agent has been eliminated or reduced in quantity.

11. In many instances, the causative toxic agent will first produce a stimulative effect; and depending upon the idiosyncrasy or tolerance of the person affected, it may, by continued introduction of the toxic agent, develop depressive and degenerative effects during the course of the same day.

4. Endogenous Toxemia:

In endogenous toxemia we are dealing with several types of pathological functions maintained within the organism. There seems to be, however, a definite line of demarkation between two general classifications. They are (1) the drainage type of infection sending micro-organisms into the system, and it is characterized in visual fields by the overlapping and interlacing effect it produces on the color outlines. Form and motion are not excessively affected by this class. (2) The locked infection is the other type, where the infection focalized in life tissue. It is frequently referred to as a focal infection. This is characterized by a decisive

restriction of the outline for perception and retention of a white target, and red overlapping blue with all colors small. Both of the foregoing, which are toxic conditions being produced inside the organism (endogenous), will show the same general field phenomenon night and morning.

The results of perimetric studies in endogenous intoxication have necessitated certain classification somewhat descriptive of the character of the toxic agent responsible for the anomalous effect obtained.

a. Auto-Intoxication, Primary Type (Drainage Type):

Effects obtained from continued operation of various systemic disorders.

The characteristic color field perception is as follows: Green interlacing with red. The relative size of the field is restricted. The stimulus of the duction is low. The symptomatology is one of general depression, ocular fatique, retinal and muscular asthenopia. Comparative color field measurements made at different hours of the day show no material change in the characteristic color field perception, the stimulus of the ductions show very little variation.

b. Auto-Intoxication, Secondary Type (Drainage Type):

Effects derived from systemic sources in more advanced stages.

(1) Red interlacing with blue is characteristic. The field for red and blue very frequently contract to such an extent that they may very often be described as being within the blind spot and point of fixation.

(2) The interlacing effect of the red over blue and the relative size of the field remain unchanged during the course of the day.

(3) Fundus examination may reveal enlarged veins, and optic neuritis may be present. On the other hand, the fundus may be entirely negative.

(4) Neuritis and gastro-intestinal disturbance are common complaints.

c. Focal Infection (Locked type - dental) Abscessed tooth:

Among endogenous toxemias there are certain types of infections that create an excessive depression of all fields except that for motion. In this field phenomenon all colors and form fields will be exceedingly small, within 15 to 20 degrees, and both

restriction of the outline for perception and recognition of a white target, and red overlapping blue with all colors small. Some of the foregoing, which are toxic conditions being produced inside the organism (endogenous), will show the same general field phenomenon night and morning.

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(3) Fundus examination may reveal enlarged veins, and optic atrophic may be present. On the other hand, the fundus may be entirely negative.

(4) Neuritis and gastro-intestinal disturbance are common complaints.

c. Focal Infection (Septic Type - Generally Depressed Fields):

Among endogenous toxaemias there are certain types of infections that cause an excessive depression of all fields except that for motion. In this field phenomenon all colors and form fields will be exceedingly small, within 10 to 20 degrees, and much

eyes will register the collapse even though one eye will be more advanced than the other. The condition will be manifested both morning and evening.

Such small fields, if present at all hours of the day, are indicative of foci of infection, that is, the infection is gathering into a focal spot, a localized region, and is not of a drainage nature. Very frequently there is formed a walled-off pus pocket, or abcess. This may be located anywhere in the body, but in 90 percent of the cases it is an oral infection.

Although dental infection is the most frequent of sources of focal infections as indicated in visual field practices, it is by no means the only source. Cases have been described in which focal infection produced the described field phenomena from a gathering in lung tissue that caused lower lobar pneumonia three days after the diagnosis of focal infection was made; of appendicitis, although it more frequently registers the field indication of the depressive stage and of the drainage type of infection rather than the locked type under discussion; of an infection in the foot from chronic irritation from a nail projecting into a shoe, etc.

Cases showing the typical focal infection fields will not respond to vision training so rapidly, and although some improvement may be noted during the course of training it will not remain for long. Visual conditions will not show much improvement until the toxic source has been eliminated. Experience has shown that the safest procedure is to give the best lens correction and refer the patient for outside treatment. After the elimination of the toxic source, another analysis of the visual condition should be made. An entirely changed situation may exist.

Summary:

(1) Any interlacing or overlapping effects of the characteristic color field outlines is abnormal and apparently indicates an improper balance of chemistry of the organism. Comparative tests are absolutely essential. Fields may at certain periods of the day, apparently, show nearly normal color fields due to the dual actions of an endogenous toxic agent and the stimulative effects of an exogenous agent, producing an apparently normal condition.

(2) Dental infections may show the primary, secondary, or focal infection fields, or a person may have a dental infection without producing any variance in the fields. A negative set of visual field charts does not prove that there is no source of infection, but a positive visual field does indicate a toxic source.

(3) Keep in mind that overlapping, interlacing of color outlines morning and evening, with relatively no affection of form and motion fields, indicates an auto-intoxication of the drainage type. This may be an oral infection or in any part of the organism. A collapsed field for form and color morning and evening is indicative of a focus of infection, and this likewise may occur anywhere in the body. However, of this latter type, nine out of ten have been proven to be found in the mouth.

B. Blind Spot Enlargements:

In mapping the blind spot, it is very important to note the direction in which the enlargement takes place. In myopia and toxic amblyopia, the enlargement is toward the point of fixation. In sinus infections of sufficient intensity to affect the blind spot, the enlargement is more or less concentric.

1. Seidel's Sign:

This is considered an early phase of the Bjerrum's sign with the blind spot enlargements appearing above and/or below and toward the center of fixation. In this instance the scotoma follows along the nerve fibers which pass above and below the macula toward the raphe.

2. Bjerrum's Sign:

When complete, the scotoma is comet in shape or sickle-like. It extends from the upper or lower edge of the blind spot, above or below the point of fixation to the raphe in the center along the horizontal meridian. If the process is complete above and below, an annular scotoma will be present in which the blind spot of Mariotte is included.

Peter claims that many Bjerrum's signs begin as detached areas above or below the fixation center between the tenth and twenty-fifth degrees. The scotoma at first is indistinct for green, then relative in which green is lost first, and, finally absolute. In order to detect the first sign of its presence, a 1 degree green stimulus is the best to employ.

3. Roenne's Nasal Step:

A step-like defect of the superior or inferior nasal quadrant in the nasal field. The nasal sectors are the first to show contractions, developing into complete nasal loss as both upper and lower quadrants become involved. In point of time it is probable that these nasal sector defects precede the complete loss of the nasal field. As they are early signs of glaucoma, they often are overlooked unless careful studies are made of the peripheral and central fields. The nasal step may occur with or without the Bjerrum's sign. In development it is like the Bjerrum's sign

and, in most cases, a part of this sign.

4. Elliot's Sign:

This is similar in character to the sign of Seidel. Elliot believed that instead of a single point to the cresent, there might be several of these points.

5. Transitory Visual Aphasia:

This is a condition of temporary enlargement of the normal blind spot, or the creation of a temporary new blind retinal area from binocular dysfunction. This has proven to be far more common than ordinarily suspected.

There are a number of conditions representing a concession in the visual act such as monocular amblyopia, squint, functional myopia, alternating right and left eye vision, and many others. Each of these conditions represents the results of an advanced stage of an interference in the co-operation of the two eyes, known as binocular vision. These advanced stages of concessions have occurred only after early attempts have been made to avoid trouble.

If these concessions are the results of interference in the binocular act of seeing, then we may suspect that the first, or early, signs of the interference would be manifest when other visual skills begin to become impaired. Also we would suspect them to become more pronounced when the reading load increases. (Reading here refers to "maintained and sustained visual concentration within restricted areas".)

The visual problems encountered in an optometric office have been brought on because the patient has been using his eyes in visual concentration in restricted areas and for limited types of use. His visual environment has been an utterly artificial one, one for which nature has made no (or at least inadequate) provision. It is the using of eyes under these conditions that create visual problems. In contrast, the person who performs no job requiring visual concentration has no visual trouble.

The child in school is in an environment artificial to his natural visual abilities. If he <u>learns</u> the visual skills involved to permit near point concentration, he has no troubles with vision or comprehension. If he fails to accomplish this, visual symptoms will appear. These are at first, of course, the symptoms we find during the analysis procedure, and do not at this early stage create discomfort, strabismus, or blurred vision, or any other symptoms obvious to the patient himself.

It has been found that frequently young patients of the pre-adolescent stage make a very dramatic concession in an attempt to eliminate the disharmony created in forcing the bino-

cular function. It is ignoring energy transference from areas of the retina, a blocking of sensory impulses. This usually occurs around the blind spot, but may spread to include the entire retina, though it rarely includes the macula. The skill of reading obviously will be impaired while one or both eyes have enlarged blind areas, and especially if only a small area at the macula remains receptive.

In as much as the creation of enlarged blind spots is the direct result of disharmony in the binocular function while doing maintained visual work, they are created only after a period of reading. Usually a twenty minute period of concentrated visual maintainance will bring on the enlargements if the person is subject to them. Also they will disappear when reading is discontinued for a while, or if reading is pursued while one eye is occluded.

In the case of persistant blind areas it is difficult to differentiate transitory visual aphasia from pathological scotomata. If the blind area remains after the young patient has been outdoors playing, it may be suspected as arising from pathology. Control test later, after occlusion of the better eye, will tell. If it is transitory, then solving the visual problem will prevent recurrences.

These highly transitory blind spots are not found in well developed squints, well developed amblyopia exanopsia, or monocular vision. In these cases the problems have been solved by the visual defect itself.

Another phase of disharmony that sometimes produces enlarged blind spots is the incongruity of coordination of hand and eye. Right eye and left hand dominance, and left eye and right hand dominance are the most frequent circumstances.

In right handed people perception of the printed or written word is formed and their memories stored in the center of the left occipital lobe, and from this area impulses pass along the association fibers beneath the angular gyrus to the base of the frontal convolutions and the base of the middle frontal convolutions where are stored the impressions of speech and writing respectively.

The foregoing is, of course, an accepted description of visual impulse in persons who have a right hand and right eye pattern of dominance well formed. It is safe to assume that in persons with a pattern formed for left hand and left eye dominance the same would be true in opposite brain areas. It is when a dominance pattern has been formed in an association and then an attempt is made to change them that results in trouble. This has been noted when parents or teachers have attempted forcing a change from left to right handedness and the once formed pattern is thus violated. Such a circumstance constitutes a visual interference fully as much as any of the ordinary interferences we encounter. As a result any or all of the concessions that are made from ordinary visual disturbance may be made from this type of interference.

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C. Scotomata and Their Classification:

All defects in the visual field, which do not extend to the periphery are properly designated scotomata, that is, they are insular-like spaces of defective vision, lying within the field, and surrounded by more or less normal field.

The only normal blind spot in the field of vision is the blind spot of Mariotte, which represents the entrance of the optic nerve into the eyeball. Any other blind area within the normal field of vision for a given patient are pathologic, and represent alterations in function or structure of parts of the visual pathway. These blind areas may be small or large, regular or irregular in outline, distinct or indistinct, depending upon the lesion which causes them.

Indistinct Scotoma:

Patient is unable to define a sharp line of demarkation between the point clear vision and the absence of vision.

Relative Scotoma:

This is an area in which form may be seen, but in which one or more colors (red, blue, or green) are not recognized.

Absolute Scotoma:

This is a blind area in which the patient cannot perceive form, color, or light. It is a totally blind area in which the light sense is totally absent. The difference between these classifications is one of degree.

Positive Scotoma:

Patient is conscious of a blind area in his field and actually sees an absolutely dark, or clouded area, projected into space. Causes can be; peripheral lesions, as choroidal or chorio-retinal areas of pathology, or congenital defects.

Negative Scotoma:

Patient is not conscious of a blind area in his field and does not perceive an absolutely dark or clouded area projected into space. In this case the defect is not discovered until the field is taken. Cause: Disturbance affecting the transmitting portion of the retina.

Central Scotoma:

Location within the central zone and may include the macula, a condition which is common in retrobulbar neuritis or toxic amblyopia in which the papillo-macular bundle of nerve fibers is diseased.

Peripheral Scotoma:

Location within the peripheral zone of the field.

Pericentral Scotoma:

The point of fixation being at, or about, the center of the defect.

Paracentral Scotoma:

The point of fixation being near or at the edge of the scotoma.

Caeco-Central Scotoma:

The scotoma includes the macula and the blind spot of Mariotte.

Ring Scotoma:

A defect about, but excluding the fixation point.

Unilateral Scotoma:

One eye affected. Implies defect in retina or optic nerve anterior to chiasma.

Bilateral Scotoma:

Both eyes affected. Signifies lesions in both pre-chiasmal tracts or else a post-chiasmal lesion.

Symmetrical Scotoma:

Corresponding areas in both eyes are involved.

The nomenclature of scotomata is somewhat confusing since the same scotoma may be properly indicated by several different names.

In toxic amblyopia we may have a scotoma that is central, relative, and often negative. A negative scotoma may become positive.

An absolute scotoma may be either positive or negative, according to the position in the field that it occupies, and as to whether it is, or is not, projected as a blind area before the vision of the patient.

Whatever the form of the scotoma may be, either absolute or relative, positive or negative, an absolute scotoma permits of no further subdivisions except as its form or location is concerned. We may find scotoma areas for color as we have for form, and may

find that so far as position is concerned the same nomenclature is applicable.

Hemiachromatopsia:

Is the inability to recognize color in one half of the field.

Parachromatopsia:

Is a term for incorrect perception of color.

Dyschromatopsia:

Means a difficulty in distinquishing colors.

D. Hemianopsias:

Contraction of the field, usually bilateral, in which the half of the field to one side of the vertical meridian, passing or not passing through the fixation point is lost.

It is often observed clinically that there remains in such fields about the fixation point, a small area of retained fixation.

1. Vertical Sector Shaped Defects:

a. Heteronymous hemianopsia:

(1) Bi-temporal hemianopsia:

The temporal halves of the fields are partly blind to sensations of light. The lesion is located in the chiasmal region, involving the decussating fibers to the nasal sides of the retina. In many cases of bi-temporal hemianopsia the line of division is an exact vertical one and in others has a curve avoiding part of the macular region. An ophthalmoscopic examination may or may not reveal the presence of a choked disc.

(2) Bi-nasal hemianopsia:

The nasal halves of the fields are partly or totally blind to sensations of light. The lateral fasciculi of both sides of the chiasm or both optic nerves are coincidentally involved. A bilaterally symmetrical process implying an equal degree of involvement of the two eyes suggests as a rule a distant, often cerebellar lesion, with secondary hydrocephalus. A similar involvement in the absence of a tumor may occur as originally suggested by

Knapp through the pressure effects of diseased and sclerotic vessels.

b. Homonymous hemianopsia:

Homonymous hemianopsia exists where corresponding halves of the two fields are defective, as right homonymous hemianopsia when both right fields fail, and as left homonymous hemianopsia when both left fields fail.

2. Horizontal Sector Shaped Defects:

a. Altitudinal hemianopsia:

Implies a loss of function of the entire upper half of the commissure or two similarly placed lesions impairing the function of the upper half of each optic nerve.

b. Upper homonymous quadrant anopsia:

Upper fields of both eyes impaired, lesions located at the lower lip of contra-lateral calcarine fissure.

c. Lower homonymous quadrant anopsia:

Lower fields impaired, the lesion is located at the upper lip of contra-lateral calcarine fissure.

E. Sector Defects:

Any involvement of the field comprehended between two of its radii and its arc, all forms of defects, be they quadrant shaped, a hemisphere (hemianopsia) or even greater areas, may properly be concluded under this heading, when such defects beginning at the periphery, infringe upon the field.

Sectorial defects in one eye only indicate a lesion in the nerve of that side, anterior to the chiasm.

Bilateral sectorial defects indicate a lesion in the chiasm, in the tractus, or even more posterior.

F. Pathological Fields:

Visual Fields in Glaucoma:

No ocular disease is more intimately associated with visual fields than glaucoma. Its affection of the retina is so definite and its course of progression so well understood that no case need go unnoticed in routine optometric practice. The creation of blind areas in the field will usually occur before ophthalmoscopic examination will reveal the classical excavation of the disc. Because ocular discomfort is a relative thing, people will very frequently neglect the first symptoms of pain in glaucoma. It will

be up to the optometrists to locate glaucomatous symptoms if the disease is to be discovered early. Fields give valuable information in the early stages. In the acute stage where its presence is obvious otherwise, fields are valueless.

Glaucoma itself is a condition wherein a pressure is formed inside the eyeball greater than within the normal tension limits. It is thought to be caused by either a decreased ability in the drainage of the eye, or an increased secretion, or both. As a result the greater liquid volumn causes a tension against the walls of the eye and thus pressure is increased against nerve fibers, blood vessels, etc. Sometimes the pressure even further hinders drainage. Some authors state that the increased pressure also decreases nutrition. The exact nature of the disease, and all its possible causes and effects, is not our problem here, but the mechanics of it gives light on how the visual fields are affected. One of the first field signs of glaucoma is the enlargement of the physiologic blind spot, specifically from above and below. At first the enlargements will be finger-like projections from above and/or below the normal blind spot curving around the macula. It bears the name "Seidel's Sign" since Seidel was the first to discover and proclaim this phenomenon.

As the pressure and time of affliction increases, the length of these blind areas increases. Bjerrum called this a sickle-shaped scotoma, and today it is called Bjerrum's Sign. As the Bjerrum scotoma increases in length it encircles the macula and may even develop into a ring scotoma. This ring begins at the physiologic blind spot, and as it increases, the concave side is always toward the macula. Occasionally we may find a curved defect not conected with the blind spot, but isolated. This, however, will be found to be in a curved line of direction with the blind spot and if the scotoma were continued it would run into it.

Another very common sign of glaucoma is a sector defect in the nasal field. Roenne named and described this phenomenon. It affects the peripheral limits of form and motion fields. Although it is not common to find this defect as a temporal sector loss, it is most generally in the superior or inferior nasal field.

In chronic glaucoma, recognized departures from the normal field manifest themselves as follows:

1. In early loss of the nasal field.

2. In sector-like defects of the superior or inferior nasal quadrants (Roenne's nasal step).

3. In enlargement of the normal blind spot of Mariotte (Bjerrum's sign).

4. In concentric contraction of form and color fields.

5. In preservation of central vision for form and

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4. In concentric contraction of form and color fields.

5. In preservation of central vision for form and

colors, even though peripheral fields are cut to a small central area.

6. In almost complete loss of the peripheral field with:

   a. Preservation of a small temporal area and a small island, or:

   b. Total loss of central vision.

While clinical experience vary among various men, in general, the order in which these symptoms have been noted is the order of frequency as well as approximately the order in point of time, when the phenomena appear in the life history of the average case.

The early loss of the nasal field is explained by Peter, stating that peripheral vision is largely the result of the condition of circulation. The larger area supplied by the temporal branches of the central artery of the retina, and the longer detour necessary to reach the most peripheral parts of the temporal retina, are assigned as the cause of the early shrinkage of the nasal field, a symptom which is noted both in the acute and chronic variety of glaucoma. The rod and cone layers of the retina receive their nourishment from the choriocapillaris, which is evenly distributed over the entire extent of the choroid. It is probable, therefore, that the early loss of the nasal field in acute glaucoma indicates what may be anticipated in the chronic variety.

Second in importance to the early shrinkage of the nasal field is the concentric contraction of both form and color fields.

It is characteristic of glaucoma simplex that central vision is preserved until peripheral vision has almost disappeared in many instances, and the extent of contraction is the only guide to the progress of the disease.

Another type of field change observed in glaucoma is the sector-like defect which often extends to, and at times, includes, central fixation. The tendency of the nasal field to shrink is not only an early symptom, but later is manifested in the formation of the sector-like defects under discussion. These defects are usually observed on the nasal side, and a superior or inferior nasal quadrant is therefore often noted.

The usual perimetric examination with a standard 5 millimeter target indicates, in the early stages of glaucoma simplex, only a concentric contraction of the entire field. It is therefore advisable, whenever these contracted fields are encountered, to use the Bjerrum technique of graduated test objects on the perimeter. The Roenne step may be discovered with a small target a month before the progress of the disease indicates this phenomena

with a larger test object.

Finally, not only the peripheral field is involved in glaucoma but the central zone is also subject to changes, and when carefully sought, central paracentral, peripheral, and ring scotomata may be charted. Quantitative central field studies date from Bjerrum's idea of 1889. With a black velvet curtain marked off in 5 or 10 degree circles, and using graduated test objects, usually white, he was able to show in normal cases, a series of concentric isopters for the series of test objects; he could reduce the field size within the possibility of a flat surface, but was also able to make graded tests of the central areas and showed their peculiar indications which at that time were almost unknown.

All glaucoma central defects are connected sooner or later with the blind spot.

There are three types of enlarged blind spots found in glaucoma, which are named after their discoverer. They are in the order of their development, the Seidel's Sign, the Bjerrum's Sign, and Roenne's Nasal Step.

The Seidel's Sign is a slender prolongation from the blind spot, running up or down, or both up and down, described by Seidel as sickle scotoma. It is a very early sign of glaucoma and may grow into a ring scotoma or Bjerrum sign or it may disappear, leaving either a normal or enlarged blind spot. The Seidel's Sign is not found by ordinary methods on a perimeter. The Bjerrum idea of very small serial white test objects upon the Stereocampimeter will disclose the defect if present.

The Bjerrum's Sign develops from the Seidel's Sign and is a finger-like process which reaches from the upper or lower part of the blind spot, or both, toward the fixing area. This is not easy to find when its defect is for color, unless a campimeter with graduated targets is used.

The Roenne Step can be found with a campimeter, but best with graduated small test objects. It is a very late sign and often explains the sudden failure of vision in a case of long standing chronic glaucoma. If we depend upon the visual acuity alone, one of these losses in the form of an inferior nasal quadrant anopsia can slowly develop, and for a long time there may be only a few degrees between the total loss of the all important fixing area.

Discussions in Technique:

The following facts must be noted in the chart:

a. Corrected vision, O.U.

b. Size, color, shape of test object.

with a larger test object.

Finally, not only the peripheral field is involved in glaucoma but the central zone is also subject to changes, and when carefully sought, central paracentral, pericecal, and ring scotomata may be charted. Quantitative central field studies date from Bjerrum's loan of 1889. With a black velvet curtain screen with 5 or 10 degree circles, and using graduated test objects, usually white, he was able to show in normal eyes, a series of concentric isopters for the series of test objects; he could reduce the field size within the possibility of a flat surface, but was also able to note graded faults of the central areas and showed their peculiar indications which at that time were almost unknown.

All glaucoma central defects are connected sooner or later with the blind spot.

There are three types of enlarged blind spots found in glaucoma, which are named after their discoverer. They are in the order of their development, the Seidel's Sign, the Bjerrum's Sign, and Ronne's Nasal Step.

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The Ronne's Step can be found with a campimeter, perimeter with graduated small test objects. It is a very late sign and often explains the sudden failure of vision in a case of long-standing chronic glaucoma. If we consider the visual acuity fibers, one of these losses in the form of interior nasal quadrant defects can slowly develop, and for a long time there may be only a few degrees between the total loss of vision and impending fixing area.

Discussions in Technique:

The following factors must be noted in the charts:

a. Perimetal distance, C.S.

b. Size, color, shape of test object.

c. Test distance.

d. Type of fixation target.

e. Illumination.

f. If upper lids retracted or not, or any change in position.

g. Cooperation of patient.

A 5 millimeter target is used for average cases but it is not always sufficient. Any irregularities should be tested with 2/330 or preferable also 1/330. Particular attention should be paid on the nasal side. The perimeter arm is rotated up and down a few degrees from the horizontal and reading taken in each position.

Color Fields Suffer in Direct Proportion to the White or Form Field.

Central fields are checked on the tangent screen, preferably a 1 - meter screen. The blind spot is charted with 2/1000 or 1/1000 if visual acuity is good.

a. Marked irregularities usually due to wavering fixation.

b. A good general rule is to start examination with smallest test objects which can be seen at the edge of the screen.

c. Occasionally may find blind spot apparently normal in presence of cupped disc. Here one may find a Bjerrum scotoma not connected with the normal blind spot. In order to locate this, a small object 1/1000 or 2/1000 should be moved downward from the upper portion of the screen along a line about one-half way between the blind spot and fixation point, the patient being instructed to note if it suddenly grows dim or disappears. Then he should be told to note when it reappears, still moving object downward. This gives location and approximate boundaries of the scotoma.

d. Frequently the scotoma may be entirely relative -- that is, there is no area of absolute blindness -- only a dimming of the test object. In such cases, use colored test objects but caution must be used. The target may disappear and reappear in a puzzling manner as patient shifts fixation slightly. A slight reduction in illumination of the screen will change such relative scotoma into absolute.

e. Finally, the entire extent of the field should be

checked with a 1/1000 test object.

(1) At 2000 millimeters a normal field for 1 millimeter is about 26 degrees.

(2) At 1000 millimeters a normal field for 1 millimeter will practically cover the ordinary tangent screen provided no opacities are present.

f. Marked reduction must be regarded with suspicion.

G. Special Pathology of Fields:

1. Study of changes observed in specific instances of organic disease can be made most systematic by dividing the visual pathway into:

a. Intra-ocular portion, including the choroid, retina, and nerve head.

b. Optic nerve proper.

c. Chiasm

d. Posterior part of the visual pathway, including the optic tract, primary optic center, optic radiation, and the cortex concerned in vision.

2. Diseases of the Intra-Ocular Portion of the Visual Pathway:

a. Hard to draw sharp line dividing diseases of the choroid and retina.

b. One is usually accompanied by the other.

c. There are certain broad differences between early field changes in diseases of the choroid and retina:

Whether a case in point should be choroido-retinitis which is essentially choroiditis with retinal involvement, or retino-choroiditis which implies retinitis with choroidal involvement.

d. For purposes of simplification and study, the following table of the essential differences is offered:

CHOROIDAL DISEASE	RETINAL DISEASE
(1) Early island-like defects.	(1) Diffuse defects, following the branches of the central retinal artery and

	the nerve fiber distribution.
(2) Multiple scotomata.	(2) Diffuse but irregular contraction of the red and green fields, and to a less extent, the blue and form fields.
(3) Ring scotoma.	(3) Sector-like peripheral and central field defects.
(4) Scotomata may be positive or negative.	(4) Scotomata, if present, are negative in character.
(5) Early loss of blue and yellow fields.	(5) Early loss of red and green fields.

e. Choroidal Pathology:

(1) Essentially is localized and insular in character with a tendency to coalescense as the pathology progresses.

(2) Corresponding field changes consist of island-like defects scattered over the field.

(3) In some instances scotomata may coalesce and form so-called ring scotoma.

(4) Late in the disease, peripheral contraction of form and color is added.

(5) Choroidal pathology causing disturbance of the rod and cone layers:

Early loss of the blue field, out of proportion to the red and green.

(6) Choroidal pathology disturbing the inner layers of the retina:

Contraction of red and green, with fairly normal blue and form fields.

(7) In choroidal disease, if a contraction for red and green is equal to, or greater than that for blue, and a negative scotoma instead of a positive one, it is probable that the inner neuron of the retina has become involved as well as the outer neuron and the choroid.

(8) In all types of choroiditis, as a rule, field changes will correspond to the pathologic

changes observable with the ophthalmoscope.

(9) Contraction of the peripheral field for form and colors is rarely observed in choroiditis, but when present, it is an indication that the retina and particularly the axis cylinders and the inner neuron of the retina have become involved.

(10) Syphilis (lues) and tuberculosis are the acknowledged etiologic factors.

f. Disease of the Retina:

(1) Follows the central retinal artery and nerve fibers.

(2) Characteristic form of field defect is irregular contraction of the periphery for form and color and an occasional scotoma.

(3) Choroido-retinitis juxta-papillaris -- a sector defect may extend from the blind spot of Mariotte to the periphery without any other disturbance of the field. Starts as an enlargement of the blind spot, but promptly includes an entire sector to the periphery.

Not unlike a Bjerrum scotoma.

(4) Primarily an inflammation of the ganglionic cells and their axis cylinders or nerve fibers which make up the optic nerve.

(5) Differs from choroiditis because of:

(a) Differences in the blood supply.

(b) Peculiar distribution of the nerve fibers to various parts of the retina.

(6) Arrangement of the blood vessels in the choroid tends to the development of foci of disease, whereas the distribution of the central retinal artery tends to diffuse forms of inflammation which may involve the entire retina.

(7) Characteristically, a contraction of the field for form and color is more in evidence than scotomatous areas as observed in choroiditis.

(8) Reduction in the blue field is commensurate with that for form, but red and green suffer to a greater extent.

(9) When focus of greatest intensity in central or intermediate zones, may show contraction for red and green out of proportion to that for form.

(10) Sign of early retinitis when under subdued light, red and green fields are contracted but both form and color fields are normal in good light.

(11) When well established, areas of greater intensity may cause red and green to disappear before form has shown a great degree of contraction.

g. Nephritic Retinitis (Retinitis albuminurica):

(1) Contraction of form and color fields, even in the early stages of the disease.

(2) Indistinct scotomata which later may become relative or absolute. May occur in any part of the field, but most characteristically develop in and about the macula.

(3) Enlargement of Mariotte's blind spot.

h. Diabetic Retinitis:

(1) Some contraction of the form and color fields.

(2) Scotomatous areas if present usually in the macular region.

(3) Perimetric changes similar to those found in chronic Bright's disease but milder in nature.

i. Retinitis Pigmentosa (Pigmentary degeneration of the retina):

(1) This is an atrophic or sclerosing process which involves the retina and possibly the choroid.

(2) As a rule, hereditary, occurring frequently in several members of the family.

(3) Clinically characterized by an early deposit of pigment of peculiar arrangement about the equator of the eyeball, by a waxy atrophy of the optic nerve with fairly distinct nerve head, a marked contraction of both the retinal arteries and veins.

(4) Patient complains of gradual loss of vision which is especially marked in twilight.

(5) Perimetrically, the characteristic symptoms are:

(a) A progressive and rapid contraction of the form and color fields, sometimes irregular, but usually concentric.

(b) Preservation of central vision for form and colors long after peripheral vision has become lost.

(c) Ring scotomata, in the earliest stage of the disease.

(d) Absence of central defects until the progressive loss of the form field encroaches upon central vision.

j. Medullated Nerve Fibers:

(1) Give rise to field defects directly in proportion to their number and extent.

(2) Medullated nerve fibers usually are found above and below, and in the direction of the distribution of the nerve fibers.

(3) A comet-shaped scotoma may be observed corresponding to the distribution of the opaque fibers -- resembles Bjerrum's scotoma.

(4) Scotoma is indistinct or relative; never absolute.

(5) The degree of the color defect will be in direct proportion to the density and extent of the medulated fibers.

3. Disease of the Papilla or Intra-Ocular Part of the Optic Nerve:

a. Because of the difference in etiology, and difficulty encountered in their early clinical differentiation, the following table is submitted to aid the student in arriving at a correct diagnosis:

PAPILLEDEMA	PAPILLITIS
CLINICAL SIGNIFICANCE	
Increased intracranial pressure	Inflammatory and irritative lesions.

CLINICAL EVIDENCE

Nerve head elevation, 2 to 9 diopters.	Moderate elevation, 3 diopters.
Typical descent of vessels to level of retina.	Gradual descent of vessels.
Arteries and veins slightly tortuous in retina.	Marked tortuosity of arteries and veins.
Retina not edematous in early stages.	Arteries and veins obscured in retinal edema in certain areas.
Pitting (depressions) at the peak of the elevation.	No pitting of the elevated nerve head.
Hemorrhages and exudate largely confined to nerve head.	Hemorrhages in nerve head but more marked in surrounding retina.

FIELD CHANGES

Mariotte's blind spot enlarged.	Blind spot enlarged to greater extent.
Peripheral fields show little enlargement in early stages.	Peripheral fields always contracted.
Peripheral contraction late.	Peripheral contraction early.
Central vision good.	Early impairment of central vision.

b. Papillitis:

(1) Essentially is the result of an inflammatory process along the visual pathway. It is not confined to the nerve head, but extends to the retina. Furthermore, some swelling of the nerve head is observed in most cases, but the elevation is not great.

(2) Part of or an intensive form of neuro-retinitis, in which the nerve head pathology predominates.

(3) The nerve head is obscured and merges with edema and swelling of the surrounding retina.

(4) Irregular contraction of form and color fields, which appears, in point of time, with lowering of central vision.

(5) Enlargement of the blind spot of Mariotte is

early in papillitis, but in itself is not distinctive when unaccompanied by central visual loss and by peripheral field disturbance.

c. Papilledema: (Choked disc)

(1) Primarily is a condition of congestion of the nerve head due to a mechanical cause, namely, increased intracranial pressure. As a rule it should be regarded as a distinct and separate entity. When, therefore, it exists as a separate entity, what may be regarded as rather characteristic of the condition is an enlargement of the normal blind spot without involvement of the peripheral field, and without disturbance of central vision.

(2) Instead of an absolute enlargement, an indistinct scotomatous area may be found surrounding a blind spot of normal size, in which both color and form can be determined but with uncertainty.

(3) Union of the enlarged blind spot and central scotoma will give rise to a caeco-central scotoma.

4. Diseases of the Optic Nerve Proper:

a. Optic Nerve Atrophy:

Clinically, optic nerve atrophy may be divided into: (1) primary, (2) secondary atrophy, (3) consecutive or post-neuritic, (4) retinic or choroiditic atrophy, and (5) glaucomatic or nerve bundle atrophy.

(1) Essentially, four of these clinical varieties, (excluding #5) have certain perimetric symptoms which are common to all:

(a) Color fields, especially the red and green, show evidence of shrinkage out of proportion to form and blue fields.

(b) The form field suffers in any variety of atrophy, and the contraction may be marked by entering angles.

(c) Scotomata, central or peripheral, indistinct, relative or absolute, usually negative in character, also appear in all varieties.

(2) Primary Optic Nerve Atrophy:

This classic type is the most important of the subdivisions under discussion. It includes a large number due to hereditary and acquired central diseases, local pathologic processes, as well as a fairly large unclassified group, such as atrophy due to exposure to cold, venereal excesses, malnutrition, etc. Tabes dorsalis, or locomotor ataxia, is the classic example of this variety.

(a) An early and rapid loss of red and green fields, together with concentric contraction of form and blue fields, are the usual phenomena.

(b) Nasal field, as a rule, shows the first evidence of change.

(c) Central scotomata are not unusual. When present are negative in type, and although relative at first, soon become absolute.

(d) The concentric contraction, in typical cases, progresses until all evidence of color has disappeared and only central vision remains, or complete blindness supervenes.

(e) Irregular types may be observed. The nasal field may show cutting, corresponding to the early pallor of the temporal half of the optic disc.

(3) Secondary Optic Nerve Atrophy:

The findings are similar to those found in the primary condition, with rapid loss of central vision.

(4) Post-neuritic atrophy is found after papilledema or optic neuritis. It is usual to find irregular contractions of the form and color fields.

(5) In atrophy following retinitis and choroiditis the findings are similar to those in primary atrophy.

(6) As pointed out any disease involving the chiasm or beyond show as anopsias. Needless to say, if such a condition is found a surgeon is indicated at once.

VII. FIELDS IN FUNCTIONAL NERVOUS DISEASES:

A. Hysteria:

However numerous the manifestations of hysteria may be, and of whatever character, the underlying principle is that of inhibition -- a condition in which the patient is so influenced by environment, in its broadest sense, that the personal will-power has been lost, or is so feebly active as to make him incapable of responding normally to normal stimuli.

The retina is a sensory end organ which is well adapted to illustrate the vagaries of the symptom-complex of hysteria, and the symptoms found are as varied as the complexity of the visual act would lead one to expect. Three types of changes, however, are especially characteristic: (1) concentric contraction of fields, with or without central amblyopia, (2) tubular fields, (3) reversal of color fields, and (4) steep edges.

Concentric Contractions:

Most characteristic, and probably observed most frequently, is the circular shape of the field contracted to various degrees. Contraction almost to the center may be found. What is observed most frequently is a form and color field of almost equal size. In other instances color fields may be contracted in their usual order and in proportion to the reduction of the fields, as observed in optic neuritis. This contraction may be associated with a central scotoma, or even an annular scotoma.

Tubular Fields:

If doubt exists as to the genuineness of the hysterically contracted field, further proof will be found in varying the distance between the patient and the campimeter or the screen. Parenthetically, it may be added that the campimeter is the ideal instrument with which to measure this type of field. Under normal conditions, the field will enlarge as the patient recedes from the screen. In hysteria, however, the same size of field may be obtained at all distances, a symptom which tends to confirm the hysteric character of the first type of field mentioned. This type is known as the tubular field and occurs only in
P/S hysteria and malingering.

Reversal of Color Fields:

In this field the red may be smaller than green, or as de Schweinitz believes, the red may be enlarged to reach beyond blue -- a condition possibly of hypersensitiveness to red. In all probability it is due as much to insensitivity of the retina to blue.

VII. FIELDS IN FUNCTIONAL NERVOUS DISORDERS

A. Hysteria

Whatever questions the qualifications of hysteria may be, and of whatever character, the underlying principle is that of inhibition -- a condition in which the patient is so influenced by environment, in its broadest sense, that the personal will-power has been lost, or is so feebly active as to make him incapable of responding normally to normal stimuli.

The field is a constant end organ which is well adapted to illustrate the vagaries of the symptom-complex of hysteria, and the symptoms here are so varied as the complexity of the visual act would lead one to expect. Three types of changes, however, are especially characteristic: (1) concentric contraction of fields, with or without central scotomata, (2) tubular fields, (3) reversal of color fields, and (4) other signs.

Concentric Contraction:

1. The most characteristic, and probably commonest manifestation, is the circular form of the field contracted to varying degrees. Contraction almost to the center may be found. This is observed most frequently in a form and color field of almost equal size. In other instances color fields may be contracted in which small test [illegible] is proportion to the size of the fields, as occurs in [illegible] conditions. The contraction may be associated with a positive scotoma, or even an annular scotoma.

Tubular Fields:

If there exists also the constituents of the functionally contracted fields, another trend will be found in varying the distance between the object and the observer or the screen. Characteristically it may be noted that the campimeter is the ideal instrument with which to measure this type of field. Under normal conditions, the field will increase as the patient recedes from the screen. In hysteria, however, the same size of field may be obtained at all distances, a symptom which tends to confirm the hysteric character of the field type of visual disturbance. This type is known as the tubular field, and occurs most in hysteria and malingering.

Reversal of Color Fields.

The blue field may normally be smaller than green, or as is commonly believed, the two may be interlaced. Such a condition usually is a concomitant symptom of hysteria. It is interpreted as to be due to the fatigability of the retina in [illegible].

Instead of simple reversals of color, interlacing may be found. If such a field is obtained, it should be retaken immediately with special care as to the position of the patient's head. A slight shifting to one side may be responsible for this form of defect.

Steep Edges:

The color sensations do not undergo their normal "confusion" progression but are experienced suddenly and fully recognized.

B. Neurasthenia:

The essential element in neurasthenia is fatigue -- mental and physical. The inability of the patient to concentrate and sustain thought, muscular asthenia, and its secondary irritability, are a group of phenomena which make up the symptom-complex of neurasthenia. Unlike hysteria, this condition is the result of a long drawn-out enervating process -- a product of overwork or of tension of certain forms of occupation or professions.

The perimetric symptoms are no exception to the rule in this disease. They are similar in character to the general symptoms. Fatique of the retina and inability to concentrate in conscious mental acts, are the forces which bring about the perimetric changes. It so happens that many cases of pure neurasthenia become mixed in time with hysteria, and there, the perimetric findings may be composite. This fact will account for rather complicated perimetric phenomena described in textbooks and literature as of neurasthenic origin. Essentially in differentiating between hysteria and neurasthenia, it is agreed generally that constant visual field changes are hysteric and variable field changes are of neurasthenic origin.

Fields as the Result of Fatigue:

In profound neurasthenia, if a form field, for example, is taken, beginning at the temporal side and continued indefinitely, a phenomenon known as the spiral field of von Reuss is obtained.

Providing there are no other toxic agents and factors, the color fields will be normal in their characteristic perception, and normal or medium in the morning, in relative size; and if fatique is a causative factor, a noted collapse of the field with red overlapping blue will be registered in the late afternoon hours.

In many instances the relative size of the field shows such a stage of collapse that it can readily be mistaken for almost any type of pathology.

Unlike the field changes observed in intoxication and endogenous toxemia, there are no other changes except con-

Instead of simple reversals of colors, interlacing may be found. If such a field is obtained, it should be retaken immediately with special care as to the position of the patient's head. A slight shifting to one side may be responsible for this form of defect.

Steady Phase:

The color sensations do not undergo their normal "contraction" phenomenon but are experienced uniformly and fully retained.

B. Neurasthenia:

The essential element in neurasthenia is fatigue -- mental and physical. The inability of the patient to concentrate and sustain thought, muscular weakness, and his secondary irritability, are a group of symptoms which make up the symptom-complex of neurasthenia. Unlike hysteria, this condition is the result of a long drawn-out exhausting process -- a product of overwork or of exhaustion of certain forms of perception or conceptions.

The perimetric symptoms are no exception to the rule in this disease. They are similar in character to the general symptoms. Fatigue of the retina and inability to concentrate is exhibited. Mental acts, are the forces which bring about the perimetric changes. It so happens that in many cases of pure neurasthenia there are mixed in line with hysteria, and though, the perimetric findings may be similar. This fact will account for rather complicated perimetric phenomena described in textbooks and literature as of neurasthenic origin. Essentially in differentiating between hysteria and neurasthenia, it is agreed generally that constant visual field changes are hysteric and variable fields showing are of neurasthenic origin.

C. Fields on the Mental Patient:

1. In profound neurasthenia, or a very light fatigue, the patient, beginning at the temporal side and continued indefinitely, a phenomenon known as the spiral field of von Reuss is obtained.

Providing there are no other complicating features, the color fields will be normal in their characteristic appearance, and normal or smaller in dimensions. In a relative sense and if fatigue is a prominent feature, a marked enlargement of the field with green overlapping blue will be registered in the form of difference figure.

In neurasthenia, the peripheral size of the field shows such a [illegible] of fatigue that it can hardly be mistaken for almost any type of hysteria.

Unlike the field changes observed in hysteria and neurasthenia, [illegible]

centric contraction and the interlacing effect from the normal characteristic color field perception to a red interlacing blue.

If therapeutic measures are employed and if the analysis of fatigue due to ametropia, heterophoria, or presbyopic tendencies is correct, the fields will record the process accordingly.

A low stimulus of duction in persons of middle age will often produce a very much restricted field and if corrected, the relative size of the field and the interlacing of the red over blue will indicate the progress made.

Summary: Characteristic features of a neurasthenic field:

a. Irregular contractions and expansions in different meridians, resulting in what may be called an "Accordian field", drawn out in some meridians, pushed in in others.

b. As a consequence of the foregoing, the red and green fields usually interlace.

c. Steep edges -- the color sensations do not undergo their normal "confusion" progression, but are experienced suddenly and fully recognized.

d. Patients frequently miscall colors.

e. Fields plot differently every time they are taken.

f. Lowered illumination does not make much difference to the size of the fields.

C. Wilbrand's Exhaustion Type of Field:

1. Beginning on temporal side, the test is slowly moved across the horizontal meridian, and the points of entrance and exit of test object are noted.

2. The object is now slowly passed back and across the same meridian, and the points of entrance and exit again are noted.

3. By continuing this process, these points approach nearer and nearer to the center.

4. Test may be applied to any meridian.

5. This is not a special form of field, but a convenient method of demonstrating fatigue, if present.

6. Colors behave similarly to white object, and same phenomena described for form may be elicited with any of the colored stimuli.